# HUMAN-ANIMAL INTERACTION IN THE ANTARCTIC: AN ANIMAL BEHAVIOUR APPROACH TO HUMAN DISTURBANCE OF PENGUIN COLONIES

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## DECLARATION

In accordance with the University of Cambridge regulations,

*I do hereby declare that:*

This thesis represents my own original work. Clear reference is made in the text where I make use of the work of others, and the sources of such work are stated in the reference list, according to accepted standards of citation.

This thesis is not now being submitted nor has been submitted in the past for any other degree, diploma, or similar qualification at any university or similar institution.

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AMNimon

Amanda Nimon
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# ABSTRACT

Human disturbance of Antarctic penguins is an important aspect of Antarctic conservation. It is a phenomenon which has raised concern for several decades, and has prompted the creation of guidelines for human behaviour which aim to minimise disturbance to these and other Antarctic animals. Disturbance effects of human activities have often been cited as if they were well-understood and self-explanatory; however, little theoretical or empirical research has attempted to establish their true nature, or to clarify such baseline issues as what disturbance means and when it becomes significant. Answers to these questions are offered, based on Nimon and Dalziel's (1992) concept of human-animal interaction, and values espoused in recent documents such as the *Protocol on Environmental Protection to the Antarctic Treaty*.

A framework for inquiry in this field is described. The new approach focuses on penguin behaviour, and involves specifying a) what stimulus aspects of human presence affect penguins, b) the changes in behaviour they evoke, and c) the processes by which these changes are produced. This animal behaviour approach is then applied to published reports of human-Antarctic penguin interactions in an attempt to identify the general principles that underlie such interaction.

Human disturbance is divided into three categories, the first of which is effects induced by aircraft. The discussion suggests that aircraft may represent a variety of changing stimuli, and that penguin response to human-induced stimuli will be affected by learning and situational variables such as breeding phase. The second category, approach and handling by humans, attempts to resolve contradictory conclusions in the literature, and suggests a model which may identify changing stimulus features evoked during such behaviour. The third category, an examination of effects induced by scientific methods, concludes that both penguin behaviour and welfare may be affected by studies, a finding which has implications not only for the field of disturbance research, but also for our understanding of the natural behaviour of the birds.

Based on a literature review, the arguments presented are hypothetical and must be tested. Whether further inquiry supports or rejects these conclusions, this review encourages awareness and clarifies the issues with which researchers must deal.

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Figure 1. Tourists photographing gentoo penguins Pygoscelis papua at Paradise Bay, Antarctic Peninsula (Monteath (1989), p. 17).

# OVERVIEW, DEFINITIONS AND AIMS

**Conservation in the Antarctic and the issue of human disturbance**

The recent creation of the *Protocol on Environmental Protection to the Antarctic Treaty* legitimises the view of those who see inherent value in the unique qualities of Antarctica, and must silence those who dismiss conservation principles not solidly founded on grounds of human welfare (Appendix 1). A report by the Scientific Committee on Antarctic Research (SCAR, 1984) is indicative of the spirit of the last few years: "The pressure of increasing human populations on the environment has produced a general awareness of the value of unspoilt nature or wilderness. The last remaining extensive wilderness is Antarctica" (p. 33). Unlike comparable landscapes in the Arctic, the Antarctic has never had an indigenous population. The presence of people in appreciable numbers only began there in the 1940s and 1950s, and the recency of this intrusion renders human presence and behaviour issues which are fervently debated. People with no tangible involvement passionately dispute who has the right to go there and what they should be permitted to do (Brewster, 1982; May, 1988; Roszak, 1988). The conservation of the Antarctic is not about the integrity of 14 million square kilometres of ice to which most people will never go. Antarctic conservation is emotionally and politically charged, for it represents humankind's last opportunity to act on its new-found environmental enlightenment and prove that today's generations have learnt something from the destructive practices of yesteryear which they eagerly and noisily lament.

One of the most emotionally potent aspects of Antarctic conservation is the protection of Antarctic animals. Current concerns about the plight of laboratory and farm animals highlight society's valuation of the rights of other sentient beings (Moberg, 1985b; Birke and Michael, 1992; Hampson, 1992). Whereas people are intruders in the Antarctic, seabirds and seals are the natural, and therefore may be constituted as the rightful, inhabitants.

Antarctic living ecosystems already bear the mark of human impact. From the late 18th century onwards first sealers, and later whalers, prospered from a slaughter which continued until the mid-20th century. The ensuing reduction in baleen whale numbers is often cited as a major perturbation of the Southern Ocean marine ecosystem (Croxall and Kirkwood, 1979; Quilty, 1986; Laws, 1991). Today, whilst individuals in the Antarctic may intentionally interfere with or harm animals (for example, torturing skuas which kill penguin chicks; Muller-Schwarze and Belanger, 1978), the obvious deleterious impacts on wildlife generated by human presence tend to be accidental or incidental in nature - the modification of habitat (Hemmings, 1990; Wilson et.al, 1990a), pollution (Simpson, 1976; Harris, 1991), and carelessness with hazardous materials (Woehler, 1990).

Skuas entangled in wire, seals caught in fishing nets and penguins covered in oil are easily identified as adversely affected by human presence. The form and the outcome of the impact is clear, and appropriate steps can often be taken to prevent recurrence. Yet, a less salient cause for concern has come to attract more and more attention: the possiblity that the presence of nearby people may deleteriously affect the behaviour and welfare of wildlife.

Elsewhere in the world, wild animals often flee from people. Antarctic animals generally do not, a fact that renders them particularly susceptible to humans. Parties at the first Antarctic Treaty Consultative Meeting

(ATCM) in 1961 recognised that because of this defencelessness, Antarctic animals would have to be protected from human disturbance (Recommendation I-VIII, paragraph 1).

Despite little theoretical development to establish its nature, this disturbance effect of human presence has often been treated as if it were an accepted and understood phenomenon. Popular literature is already content that Antarctic animals are being disturbed by humans (Peterson, 1973; Simpson, 1976; Tangley, 1988; Ackerman, 1989, p.40) and scientific literature treats 'visits from people' and 'scientific research' as precise explanatory variables rather than broad categories of activity (Croxall et.al, 1981; Jouventin et.al, 1984; Muller-Schwarze, 1984; SCAR, 1984; Benninghoff and Bonner, 1985, p.4). That some human behaviour should disrupt breeding activities seems to be readily believable, as this rather vague assertion has come under little scrutiny in studies on a variety of animals (Rice, 1964; Bonner, 1978; Gallagher et.al, 1984). Reliance on the self-explanatory nature of human disturbance, and undeliberated assumption that breeding success is the only parameter of interest, have fostered the general consensus that sensibly-behaved people will not adversely affect Antarctic animals and that only significant breeding failure is indicative of significant disturbance.

The most important recent developments in this field have come from a team of researchers headed by R. Wilson and B. Culik of the Institut fuer Meereskunde. Recognising that adequate knowledge cannot be developed merely through the accumulation of anecdotal evidence, they have attempted to experimentally delineate the stimulus aspects of aircraft activity, and human approach; using behavioural observation and implanted heart rate monitors, they have tried to quantify penguin responses. Their conclusions are revolutionary: the mere proximity of people may harmfully affect penguins, regardless of how well-intentioned those people may be, and although these effects might not be immediately apparent (Culik and Wilson, 1991; Appendix 2).

Because of the innovatively precise nature of their approach and, even more so, the dramatic nature of their results, this work has been reported in a wide variety of journals, and quoted by environmentalists to demonstrate the necessity of very stringent rules governing human activity (e.g. Manheim, 1990). But it is not yet time for drawing conclusions and relying on rules. These few experiments, whatever their merits, do not amount to a comprehensive coverage of the field. Results are obtained from a small number of individuals of one species of penguin, in response to isolated stimuli such as the approach of a single person. As will be demonstrated, some of their results can be re-evaluated to produce conflicting interpretations, and recommendations based on one understanding might have disastrous consequences if another were correct.

According to the definition by Nimon and Dalziel (1992), human-animal interaction occurs when the behaviour of one or more humans affects the behaviour of one or more members of another species. The components of the interaction are actions and reactions of individuals or groups of both species, present together at the same time. This definition omits behavioural change mediated through indirect means, for example, habitat modification, and focuses on Antarctic animals' response to our behaviour. As the effect of one interactant's behaviour on the other can be identified only through a change in the latter's behaviour, then all human-animal interaction can be classified as disturbing an animal.

Intuitive human understanding of harm or inconvenience caused to animals is likely to be both biased and limited. The untrained observer generally evaluates an animal's circumstances according to how the situation would affect him or her (Nimon, 1990), and even trained observers may be restricted by preconceptions. An approach to disturbance based on the above definition of interaction will be highly productive, helping researchers to avoid consciously or unconsciously ignoring change which appears harmless, thus, identifying a greater range of human-induced changes in behaviour. This range of animal responses can then be examined for their possible implications. Changes in behaviour must be understood as referring not only to the elicitation, inhibition, or modification of overt behavioural patterns, but also to physiological responses, as animals may experience heart rate and other changes without giving outward indication (Henry, 1976; Stout and Schwab, 1979; Wilson et.al, 1991). Where the term "human disturbance" appears in the text, it should be understood as referring to human disturbance of Antarctic animals (N.B. new terminology are listed in Appendix 3).

Recent attempts of Antarctic tour companies and naturalists to specifically define benign behaviours for visitors near animals (Naveen et.al, 1989; Antarctic Treaty Consultative Parties (ATCP), 1991b), as well as research efforts such as those of the Wilson team, indicate that people are both eager to avoid disturbing Antarctic animals, and frustrated at the lack of detailed guidance available to them.

Concerned parties must make a conscious break with the insubstantial and anecdotal approach to human disturbance. It is necessary to develop foundations and a framework for inquiry so that vague statements and questionable logic will be obvious for their lack of discipline against a solidly based, growing body of knowledge.

The nature of an investigation will be shaped by the context of the disturbance of interest and the threshold set for significant disturbance. These are described in Chapter One. The discussion illustrates the necessity of firm decisions about these baseline issues, and penguins are chosen as the animals of interest for this review.

This chapter also examines past and present recommendations for human behaviour in the Antarctic, some examples of which can be found in Appendices four to seven. It ends by describing an approach to human-animal interaction which provides a basic framework for knowledge sufficiently specific to enable prediction of penguin response, and the eventual creation of sound guidelines for human behaviour. The 'animal behaviour' approach is applied in the rest of the argument, beginning with Chapter Two which describes two situational variables that are likely to be important influences on Antarctic penguin behaviour, and hence, response to humans. The approach is then applied to reports of disturbance.

The effects of aircraft on penguin behaviour are the best understood form of disturbance. Responses are often of an uncontentious nature, such as fleeing. Chapter Three exploits this relative clarity of information to explore how penguins of different breeding status may be affected by varying stimulus aspects of aircraft activity. Chapter Four examines how the approach and behaviour of nearby people may affect penguins, using a less specific literature resource to develop the human approach model (Appendix 3). Such information is essential given the need to regulate increasing numbers of Antarctic visitors, yet the model predicts that the results of penguin research will also be affected by changes in penguin behaviour induced by the measurement itself. Chapter Five develops these ideas in relation to the unique problems posed by scientific study. It suggests non-invasive or less interactive alternative methods, and examines the implications of findings for our knowledge of the natural behaviour of Antarctic penguins.

Article 3, paragraph 2(c) of the *Protocol* declares that activities in the Treaty area shall henceforth "be planned and conducted on the basis of information sufficient to allow prior assessments of, and informed judgements about, their possible impacts on the Antarctic environment". Current information about human disturbance is nowhere near this stage of evolution. In summary, the aims of the present review are:

1) to provide a basis and framework for future human disturbance research

2) to evaluate available evidence and ascertain what can already be known about human disturbance

3) to encourage consideration of the multiplicity of human-induced stimuli which may affect Antarctic penguins, and of the contexts in which these effects may be relevant

4) to stimulate awareness of human disturbance of Antarctic animals in general.

# CHAPTER ONE: FOUNDATIONS AND FRAMEWORK FOR INQUIRY

## 1.1: The scope of the investigation

The first step in structuring an investigation of human disturbance is to define the context, and the limits within which the conclusions are expected to apply.

### 1.1(a): The animals involved

While there is evidence to indicate that human behaviour may affect seals (Rice, 1964; Bonner, 1978) and skuas (Ainley et.al, 1986), most of the information about human disturbance in Antarctica relates to penguins. This is probably because they are particularly attractive to people, occurring in spectacular colonies of up to one million birds (Croxall and Lishman, 1987), and inviting interaction by their entertaining, anthropomorphic behaviour. Penguins have a complex social life and are already known to respond to a rich array of cues, signals and displays in each others' behaviour (Ainley, 1975; Spurr, 1975; Jouventin, 1982), thus they are ideal animals for a study of responses to stimuli in human behaviour.

Knowledge about penguins, and of our effects on them, is important for a number of reasons. Penguins are highly specialized and biologically fascinating animals (Stonehouse, 1965a), which may comprise up to 90% of Antarctic avian biomass (Mougin and Prevost, 1980, cited in Croxall and Lishman, 1987). They have been identified by the Scientific Committee of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) as a critical component of the Southern Ocean ecosystem, information about which is essential for conservation (CCAMLR, 1985).

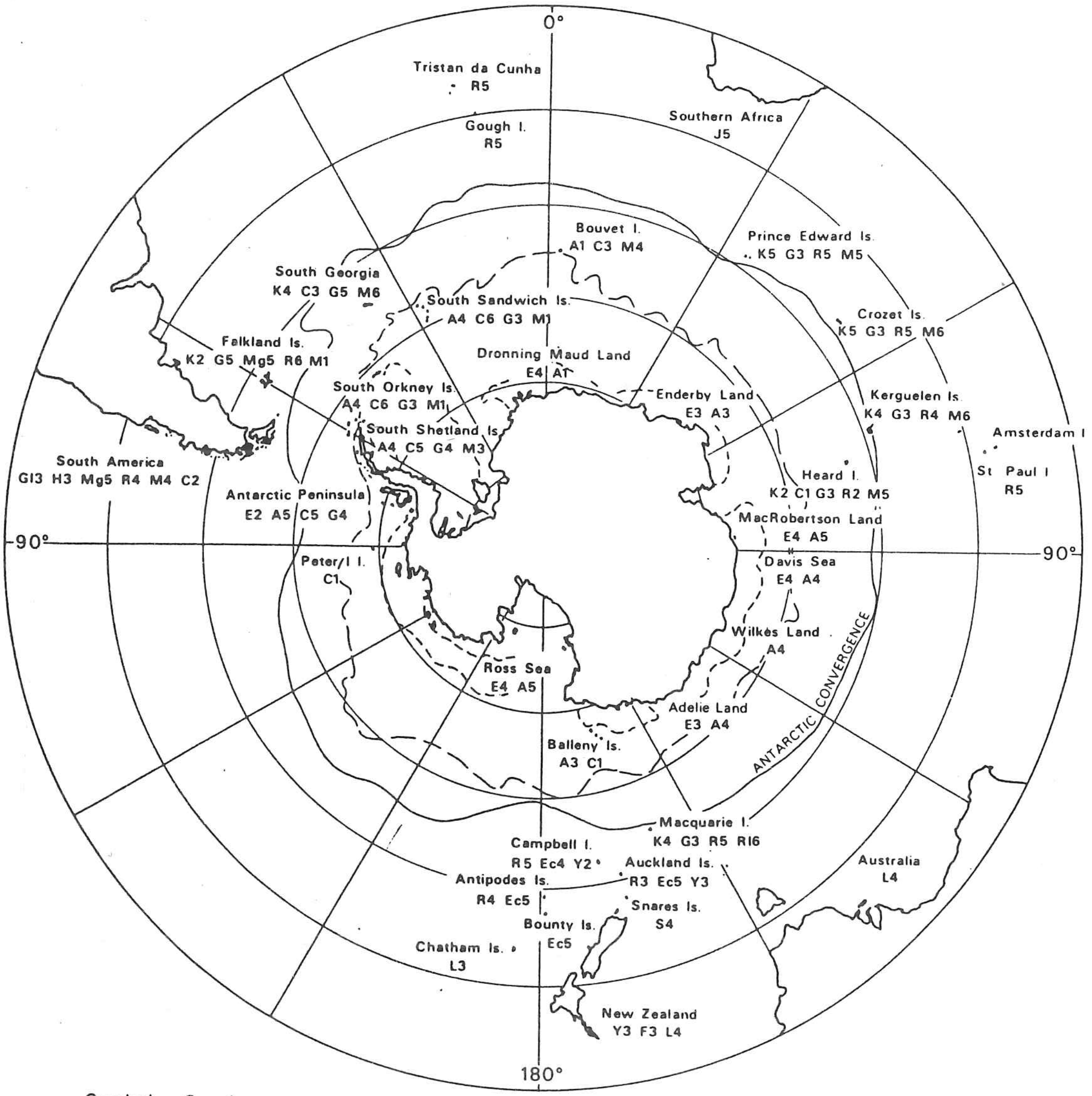
Finally, Jouventin and Weimerskirsch (1990) argue that their low breeding rate makes them susceptible to even minor decreases in adult survival.

The Antarctic Treaty area is that south of 60°S (Article IV), but the term "Antarctic" generally refers to the area south of the Antarctic Convergence. Seven penguin species breed south of the Convergence: Adelie *Pygoscelis adeliae*, chinstrap *Pygoscelis antarctica*, the southern subspecies of gentoo *Pygoscelis papua ellesworthi*, macaroni *Eudyptes chrysolophus*, rockhopper *Eudyptes crestatus*, emperor *Aptenodytes forsteri* and king *Aptenodytes patagonica* (Stonehouse, 1972).

<u>1.1(b): Where penguins are exposed to people</u>

Adelies, chinstraps, gentoos and macaronis are the species most exposed to humans, as they are found in the Antarctic Peninsula and islands of the Scotia Arc where people are most concentrated (Figure 2). The majority of stations occur in this region, and organised tours as well as private yachts routinely head for the Peninsula and one or more of the nearby island groups (Hart, 1988; Headland, 1989). Penguins are most vulnerable to humans when they come ashore to breed, in these species, between October and April. This is the period of greatest human activity, as retreating ice allows people in and out of the region, bases are resupplied and summer only visitors arrive. Adelies, chinstraps and gentoos all nest on ice-free areas of the coast where bases may coexist with their colonies and tourist ships may make landings. Adelies also breed around the continental coast, where they may be vulnerable to station activity. Macaronis may be less exposed to human interference as they prefer to nest on steeply sloping ground and tumbled cliffs (Stonehouse, 1972).

Rockhopper and king penguins are found on peripheral Antarctic islands. Those inhabitated by rockhoppers tend to be quite isolated from people.




| Symbol | | Species |
|---|---|---|
| E | - | Emperor |
| K | - | King |
| A | - | Adelie |
| C | - | Chinstrap |
| G | - | Gentoo |
| R | - | Rockhopper |
| M | - | Macaroni |
| RI | - | Royal |
| S | - | Snares Crested |
| Ec | - | Erect-crested |
| F | - | Fiordland |
| Y | - | Yellow-eyed |
| L | - | Little blue |
| Mg | - | Magellanic |
| H | - | Humboldt |
| GI | - | Galapagos |
| J | - | Jackass |

Mean pack ice limits

— — — winter

- - - - - - - summer

| Symbol | Estimated Population Size (Pairs) |
|---|---|
| 1 | 10 - 100 |
| 2 | 100 - 1000 |
| 3 | 1000 - 10 000 |
| 4 | 10 000 - 100 000 |
| 5 | 100 000 - 1000 000 |
| 6 | 1000 000 + |

Figure 2. The distribution and estimated abundance of penguins (Croxall and Lishman, 1987, p. 102).

King populations are most vulnerable to direct human disturbance during summer in regions north of the Convergence, such as South Georgia and Macquarie Island. Emperor penguins breed on the continent, but are little exposed to the summer boom of humans, as they breed mainly on sea ice in areas remote from people. Nonetheless, the first tourist visit to an emperor colony in the Weddell Sea area was made in the 1991/92 season, and more visits are planned (Stonehouse, pers. comm). Furthermore, the breeding cycle of the kings and emperors means they are ashore during winter (2.1), when they may encounter scientists or aircraft.

Most information on penguin disturbance concerns Adelies, which are the most thoroughly studied species in general (Williams et.al, 1985). Several authors believe there to be characteristic differences between species, for example, describing chinstraps as more aggressive and gentoos as more likely to run away than Adelies (Murphy, 1959; Stonehouse, 1985; Culik et.al, 1991). This suggests that interspecies differences in form, intensity and threshold of response will exist. It is also likely that a disturbance effect described for one species may not be observed at other times in other places, as there are probably a range of unidentified variables influencing response. The evidence presented represents what is available. Comment will be made where reasoning or research suggest that there will be particular interspecies differences. The degree to which a described component of human-penguin interaction applies to other interactants in other locations is a matter for further research.

1.1(c): <u>Human activity in the Antarctic: tourists and scientists</u>

Enzenbacher (1992, p.17) has defined tourists as visitors who are not officially affiliated with an established national Antarctic programme.

This definition highlights the dominant perception of human activity in the Antarctic: there are people who are officially connected with scientific programs, and there are tourists.

The term 'tourist' has very negative connotations. With its own roots deep in the history of the earliest Antarctic expeditions, the scientific/national contingent has long been concerned by this more recent intrusion, noting the disruptive effects of tourists on their environment in Recommendation IV-27. Some scientists have argued that their own impact on the Antarctic environment is negligible, consisting of local disruption in a proportionately very small area (Bonner, 1984; Laws, 1991). Other commentators are prepared to accept that scientists have an adverse impact, but see tourists as a significant turn for the worse, and have activated all the relevant stereotypes in expressing fears about "luxury hotels" and "video-arcades" (Lipps, 1978; Roszak, 1988). They draw a qualitative distinction between the actions of scientists and those of tourists "tramping on the thick vegetation" (Lipps, 1978, p. 358). Counterarguments state that *Antarctic* tourists are typically well-informed and ecologically sensitive (Simpson, 1976; Muller-Schwarze and Belanger, 1978; Naveen et. al, 1989; Anon, 1991). They point out that scientific and associated logistic activity have caused the greatest destruction of all sites, including those specially designated for research and study (Manheim, 1988; Tangley, 1988, Stonehouse, 1990).

1.1(d): People's behaviour

This preoccupation with which group of people causes the most disruption is based on human perceptions of social order and who has the right to do what. The truth is that the action causes the effect, not the intentions or source of funding of the performer. An ornithologist may be better informed than a tourist who may be better informed than an off-duty station cook, but none of them may be aware of the specific effects of his or her particular behaviours. Stations may involve a wide variety of people - construction workers, medical staff, media representatives - and there is no reason to expect that a glaciologist should either be particularly knowledgable of penguins, or inherently more careful around them than anyone else. Focusing on qualitative distinctions between the behaviour of different groups may prevent individuals from being aware of and responsible for their own behaviour, because of their perception of their membership or not of a particular group. As evidence of this, Peterson (1973) has commented that crew members of tourist ships, on shore leave, are more likely than tourists to disturb animals.

For a disciplined and objective evaluation of human disturbance, researchers must ignore these superficial distinctions and instead search for the principles underlying interaction: what stimulus aspects of human behaviours evoke what penguin responses under what conditions. A wide range of human activities evoke stimuli. Resupplying bases and field camps by helicopters or fixed-wing aircraft provide many opportunities for disruption, as do visiting and studying penguin colonies, which involve a variety of behaviours at various distances from the birds. People trying to monitor penguin behaviour may handle and otherwise engage in a whole range of manipulations, including marking and attaching devices to birds. These are the main categories of activity that are explored in following chapters.

## 1.2: Significance of disturbance

Identifying what constitutes significant disturbance is another fundamental issue in this area. Perceptions of significance are related to the values underlying one's beliefs about Antarctic conservation.

A philosophy which could be labelled 'ecologically relative significance' is espoused by those who support conservation for the ecologically sustainable use of the Antarctic (Bonner, 1984; Laws, 1991). Benninghoff and Bonner (1985), for example, argue that the significance of the adverse effects of an activity should be evaluated in relation to the perceived fragility of the relevant ecosystem. While a single penguin colony may be significantly affected by humans, the impact is less serious if many similar colonies exist (p. 7). To apply their example, detrimental impacts on a colony might not be significant in the absence of some unique or distinguishing feature of that colony.

This attitude dangerously approaches a renunciation of responsibility for one's actions on the grounds that there are many more penguins where that one came from. Even if we were to accept ecologically sustainable use as the guiding philosophy, one cannot assume that similar penguin colonies are not being detrimentally affected by other people. Furthermore, Antarctic ecosystems are not well enough understood to predict the occurrence and magnitude of all detrimental impacts which particular actions may incur.

A report by the International Union for the Conservation of Nature and Natural Resources (IUCN, 1991) also supports the ecologically sustainable use of the Antarctic, but a very strong emphasis is placed on the inherent value of the region. It also states:

> ...the conservation of nature and natural resources has to be planned to meet human needs as well as the needs of the myriads of species that have their own right to exist, regardless of their contribution to human well-being (p. 2)

A philosophy which accredits another species with a right to exist, although derided by Bonner (1984) for its lack of scientific rigour, is more conducive to caution in dealings with animals.

The *Protocol on Environmental Protection to the Antarctic Treaty* (Appendix 1), adopted on 4 October, 1991, represents a significant shift within the Antarctic Treaty System from the principle of exploitation toward the preservation of Antarctica as a "World Park" (Antarctic and Southern Ocean Coalition (ASOC), 1991, p. 1). Article 3 of the *Protocol* declares that the "protection of...the intrinsic value of Antarctica, including its wilderness and aesthetic values...shall be fundamental considerations in the planning and conduct of all activities in the Antarctic Treaty area". These values are to be protected by "limit(ing) adverse impacts on the Antarctic environment" (Article 3, 2(a)) and avoiding "detrimental changes in the distribution, abundance or productivity of species or populations of species of fauna" and "degradation of...areas of biological, scientific, historic, aesthetic or wilderness significance" (Article 3, 2(b)(iv) and (vi)). Thus, limiting adverse impact is now a "fundamental consideration" whatever one does (arguably, anywhere) within the Treaty Area.

Article 3, 2(b)(iv) clearly urges all people in the Treaty Area to plan their activities so as to avoid detrimental change in several features of any penguin colony (regardless of how many more there may be). Yet, the concerns expressed in the *Protocol* represent *a valuation of the extent to which the Treaty area has not yet been affected by the presence of people*. If we want to be able to observe and study penguins in an unaffected state, then even human-induced changes in behaviour patterns are significant. Indeed, even short-term behavioural changes are significant, as they can eventually produce permanent modifications. This can be observed in animals which have learned new behaviours in relation to a regular human presence in their environment.

Antarctic penguins are not about to be exposed to such large numbers of visitors that they would start begging for fish handouts. But people are a permanent addition to the Antarctic, and even seemingly harmless effects on penguins might have a synergistic impact over time. This is compounded by the fact that the number of visitors per year has recently begun to increase (Enzenbacher, 1992). What must be accepted now, especially in view of the *Protocol*, is that individuals can no longer afford to dismiss the local impact of their behaviour on the grounds that there are so many penguins and so few humans. We must act now to "facilitate early detection of the possible unforeseen effects of (human) activities" (Article 3, 2(e)).

The approach to human disturbance based on human-animal interaction (p. 4) encourages the identification of all human-induced changes in animal behaviour. One can then scrutinize such changes according to one's definition of significance. The *Protocol* can be interpreted as stating that all such changes are significant. Of course, it would be ridiculous to suggest that people could visit and work in the Antarctic without ever causing any observable behavioural change, heart rate increase, or sleep deprivation in penguins. However, if research on human disturbance obtains the best information possible, and people who visit the Antarctic have both access to such information and the desire to promote the spirit of the *Protocol*, then Antarctic wildlife will perhaps be preserved in a state more closely resembling "the wild" than animals in almost any other area. Such conservation would not only further the cause of science: it would be a remarkable achievement in the history of humankind's dealings with its environment.

1.3: Specific recommendations

Since the issue of human disturbance was raised in the first ATCM, there have been several attempts to delineate how such disturbance of Antarctic penguins (and other animals) could be avoided. These guidelines are based on the same commonsensical suggestions and anecdotal evidence which have fueled discussions of human disturbance, and are only capable of preventing disturbance to the limited extent to which it has been understood.

1.3(a): Attempts of the last few decades

Official guidance can be found in ATCP and SCAR recommendations. Article VII (paragraph 1) of the *Agreed Measures for the Conservation of Antarctic Fauna and Flora* (1964) advises that each Participating Government take appropriate measures to minimise harmful interference with native birds. "Harmful interference" is defined by six different categories of action:

a) allowing dogs to run free;

b) flying helicopters or other aircraft in a manner which would unnecessarily disturb bird and seal concentrations, or landing close to such concentrations (e.g. within 200m),

c) driving vehicles unnecessarily close to concentrations of birds and seals (e.g. within 200m),

d) use of explosives close to concentrations of birds and seals,

e) discharge of firearms close to bird and seal concentrations (e.g. within 300m),

f) any disturbance of bird and seal colonies during the breeding period by persistent attention from persons on foot.

Annex A to Recommendation VIII-9 (*Effects of Tourists and non-Governmental expeditions in the Antarctic Treaty Area*, 1975), provides "Guidance for Visitors to the Antarctic". Paragraph 1 is relevant to wildlife:

1. Avoid disturbing wildlife, in particular do not:
...

-touch or handle birds or seals;

-startle or chase any bird from its nest;

-wander indiscriminately through penguin or other bird colonies.

Similarly, SCAR (1984) has produced a set of guidelines, varieties of which are issued through some national programmes (Stonehouse, 1990). They explain that "by using common sense, visitors to Antarctic (sic) can make an important contribution to its conservation and avoid damaging the environment, its wildlife and vegetation". In relation to penguins, it recommends that people "not disturb nesting bird colonies (, and s)tay outside the margins of a colony and observe from a distance" (p. 36).

Although these guidelines might appear sensible, they are, in fact, quite problematic. Advice to "avoid disturbance" or use "common sense" are integral in these and other sets of guidelines not reviewed here (e.g. Muller-Schwarze and Belanger, 1978; Appendix 4). Similar to telling people not to startle birds, such directions require visitors to be on the lookout for obvious signs of distress. How do they know what signifies distress in a penguin? The birds may show no outward signs of disturbance; those with eggs or small chicks are reluctant to leave their nests, and the heart rate increase by which they may respond to approaching people (Culik et. al, 1990; Wilson et. al, 1991; Chapter Four) is not visible. Individuals will have different perceptions of what behaviour constitutes chasing or wandering indiscriminately, perhaps deducing that walking purposefully straight into a colony is permissible. Yet even a brooding bird could abandon a chick to skuas if approached to a distance of around one metre (Wilson et. al, 1991). Individual visitors also may not know whether or not they are part of "persistent disturbance".

Consideration of the necessity of an activity likely to disturb penguins is a valuable recommendation, but not a sufficient one, and it does not identify a manner of flying an aircraft which is not disturbing. The form and magnitude of aircraft-induced disturbance of a penguin colony is related to the type of craft and other variables (Chapter Three) and a blanket recommendation of 200m as a safe distance is not adequate. Sladen and LeResche (1970) report that landing a helicopter within 180m of penguins caused 50-80% of the birds to flee.

Dogs were once an integral part of the human presence in Antarctica, but a recommendation to keep them under control is of little practical significance in limiting human disturbance today. There are currently very few dog teams at only three stations (Rothera, San Martin, Mawson; Headland, pers. comm[1]), and the Protocol bans the introduction of dogs and calls for those present to be removed by 1 April, 1994 (Annex II: *Conservation of Antarctic Fauna and Flora*, Article 4, paragraph 2). Similarly, few Antarctic visitors are likely to want to use explosives or firearms, thus, another two categories of "harmful interference" have no significance for the majority of people near penguin colonies.

The remaining recommendations can be restated as follows:

From Annex A to Recommendation VIII-9:
-do not touch or handle birds.

From SCAR (1984):
-observe birds from a distance.

As one cannot handle birds if one is observing them from a distance, the advice which these official sources have to offer the average visitor is simply: stay some (unspecified) distance from penguins. This is unsurprising. In the absence of a systematic investigation of human-penguin interaction it is the most sensible suggestion to make.

1. Robert Headland is the archivist at Scott Polar Research Institute, University of Cambridge.

1.3(b): Recent innovations

Recognising that available guidelines were of little value in advising visitors how they should behave near breeding colonies, concerned groups have recently produced their own recommendations. The Antarctic Traveler's Code (ATCO) was announced on 31 July 1991 by a group of experienced Antarctic naturalists from Oceanites, an educational scientific foundation (Naveen et.al, 1989; Appendix-5). The International Association of Antarctic Tour Operators (IAATO), formed in 1991 by those organisations which have transported the majority of Antarctic tourists (Enzenbacher, 1991; ATCP, 1991a), have produced the Antarctica Visitor Guidelines (AVG; Appendix 6), which are one in a series of detailed guidelines, including advice to tour operators on promoting adherence to the AVG (Antarctica Tour Operator Guidelines).

The efforts of each group are comparable in that they both recognise that disturbance is induced by *human* behaviour and should be the concern of everyone in the Antarctic. They also attempt to identify specific behaviours in which people should or should not engage. Furthermore, they use some knowledge of penguin behaviour to try to understand what might disturb them.

Both the ATCO and AVG include the relevant recommendations of earlier guidelines - to refrain from touching penguins or entering colonies - and they specify SCAR's (1984) unspecified distance: five metres. They are appropriately phrased for a person about to visit a penguin colony, although, as Stonehouse (1990) has commented, the ATCO seems rather stern and negative. Yet, in relying on popular terminology to deliver the message (e.g. "back off if necessary"; penguins have "right of way"), the AVG, and particularly the ATCO, leave its meaning open to interpretation in different ways, and the underlying reasoning is still that disturbance occurs when it looks like penguins are disturbed (again, which can be interpreted in different ways).

The AVG and ATCO do not apply to all of the forms of human activity outlined above (**1.1(d)**). Based on their research, Wilson et.al (1991, p.368; Appendix 7) have made recommendations relating to both aircraft and people near penguins, and these will be evaluated in following chapters. However, although exhibiting some of the necessary principles, all of these sets of guidelines fall far short of what is required and can be achieved. To obtain a clearer understanding of how human-induced stimuli affect Antarctic penguin behaviour, we must change the emphasis from one of anthropocentric distinctions between human behaviours and anthropocentric indications of disturbance, and instead focus on how the penguin is likely to interpret and respond to the variety of stimuli embedded in the environment it shares with people.

**1.4: The animal behaviour approach to human disturbance**

Since Hinde's (1966) fusion of ethological theory and comparative psychology, the behaviour of an animal has been understood in relation to its evolutionary and environmental niche. Various aspects of its external and internal environment elicit the behaviour which has led that particular species to survive. Ackerman (1989, pp.39-40) has described how keepers at Sea World induce hand-reared chicks to open their beaks for feeding by making a V shape with their fingers - thus, providing the relevant stimulus aspect of its mother's beak. The V shape is an example of a sign stimulus - a stimulus that obtains its reaction evoking properties from some kind of central nervous system filtering mechanism (see McFarland, 1985, pp.210-216). Similarly, defense reactions in response to predators (Species-Specific Defense Reactions; Bolles, 1970) simply occur from the time of birth, although the appropriately emitted reaction generally changes with development.

Other stimuli, however, might be learned through experience of the consequences of emitting a particular behaviour in response to that stimulus (operant conditioning), or through association of a neutral stimulus with an inherently reinforcing or punishing one (classical conditioning). The learning which takes place, and the behaviour subsequently emitted, is determined by the animal's need to adapt to its ecological environment (Davey, 1989).

Cross-species interaction occurs through an amphigenic code (Nimon and Dalziel, 1992), a code of stimuli which has meaning to both interactants (this being inferred from a change in behaviour). However, that meaning derives from the respective species' own response repetoire and is unlikely to be the same for each. The code can be thought of as a filter, through which a stimulus emitted by one interactant emerges as a different signal on the other side.

In illustration, Nimon (1990) has described that visitors to the zoo have characteristic, anthropomorphic ways of interpreting the behaviour of various animals, and attempt to interact with them accordingly. Yet, Nimon and Dalziel (1992) have shown that such visitors may evoke reactions of which they are oblivious. They found that zoo animal behaviour was differentially affected by visitor behaviours which, to the human observer, are distinguishable in only subtle ways. For example, behaviours involving sudden movements with the arms and prolonged staring at the face of a siamang *Hylobates syndactylus*, produced a response appropriate to an interspecies agonistic encounter, whereas pointing, laughing and leaning forward had no such effect. Although it seems to the visitors that the apes are becoming excited or lively, they were, in fact, responding to a threat.

Penguins also have their own ways of interpreting their environment. These represent the tools available to them in interpreting new elements in their surroundings. For example, it may be that a helicopter would be more disturbing than a ground vehicle of the same size and noise level, because the helicopter includes the additional stimulus property that it travels in the sky, as do the birds who are their only traditional land-based predators. Because the penguin's interpretation of events in its environment is not likely to correspond to our interpretation of those events, it is not wise to leave people to behave according to their own perceptions of what will disturb a penguin.

To make progress in human disturbance research, it is important to attempt to understand the penguins' world - what are the major influences in their lives and how do they respond to them. Evidence of how penguins appear to have reacted to human-induced stimuli must be evaluated in this light. The following chapters draw attention to the few relevant experiments, and squeeze information from anecdotes, to identify aspects of the amphigenic code elicited in our behaviour, the reactions they evoke, and the situational variables which may modify the stimulus-response connection.

The animal behaviour approach meets the requirements that have been identified in chapter one. It focuses on the fundamental action-reaction level of disturbance, produces the precise details necessary for the specification of guidelines, limits anthropocentric bias, and allows for prediction of how disturbance may vary with a change in circumstances. In short, it provides an objective, disciplined methodological and theoretical foundation for this field.

# CHAPTER TWO: IMPORTANT DETERMINANTS OF ANTARCTIC PENGUIN BEHAVIOUR.

The breeding status of a penguin determines much of its behaviour. The behaviour of surrounding penguins also influences that of the individual. These factors, which are important aspects of an Antarctic penguin's interaction with its natural environment, are likely to exert significant influence on the birds' responses to new or unusual stimuli invoked by humans.

## 2.1: The breeding cycle

Antarctic penguins coming ashore for breeding follow a tight schedule of stages, enabling chicks to reach a certain threshold of development in time to fend for themselves over winter. Thus, much penguin behaviour ashore is oriented to the requirements of these stages in ways which will certainly affect response to humans. The most significant distinction between stages is that birds with eggs or small chicks must protect their offspring from adverse stimuli, those without are free to flee from anything which evokes fear. However, the implications of behavioural change, as well as the form of response, will vary with breeding phase. If an unencumbered Adelie is induced to walk away it is being disturbed, but the same reaction may cause breeding failure in incubating or brooding birds whose eggs or chicks are exposed to cold and predation.

As the timing of disturbance in relation to breeding is of considerable significance, it is important to begin with some understanding of the predominant activities and colony composition over the breeding cycle. This can be briefly summarised as follows:

The three pygoscelids and the macaroni penguin are present in colonies for only a few months, and their cycles are reasonably comparable (Figure 3). During incubation and brooding one member of the pair remains on the nest while the other forages at sea, but partners relieve each other more frequently at the latter stage, so there are generally more birds ashore at this time than during the long and solitary incubation phase. From December onward, juvenile non-breeding birds may also visit the colonies and go through the motions of courtship. After a few weeks of life, chicks are large enough to form creches and both parents forage at sea, returning periodically with food. Chicks gather on the beach when ready to fledge. Once they have left, adults moult and then also depart for the winter.

The breeding activities of king and emperor penguins are similar to those described in Figure 3, but their cycles are longer as they have larger chicks to raise. Emperors are able to fledge chicks contemporaneously with the smaller species by starting to breed much earlier in the season. Eggs are laid and incubated in winter, when the male of the pair takes the entire incubation period of about 65 days (Robertson, 1990). Females generally return just as the eggs hatch. As summer approaches, colonies are home to rapidly fattening chicks, and parents of both sexes can be found there feeding them.

King penguins on South Georgia adopt a 13-14 month cycle. Like the smaller species, they lay and incubate from November onward, but incubation lasts about 54 days. Adults leave the colonies from April and May; the half-grown chicks remain in creches to be fed at long, irregular intervals. They loose weight through winter and may die. Birds whose offspring die lay in the following November; those whose chicks survive fatten them during November and December, then lay again in January and February (Stonehouse, 1972; Muller-Schwarze, 1984). The timing of these phases varies with location, for example, on Iles Crozet most laying occurs later than on South Georgia

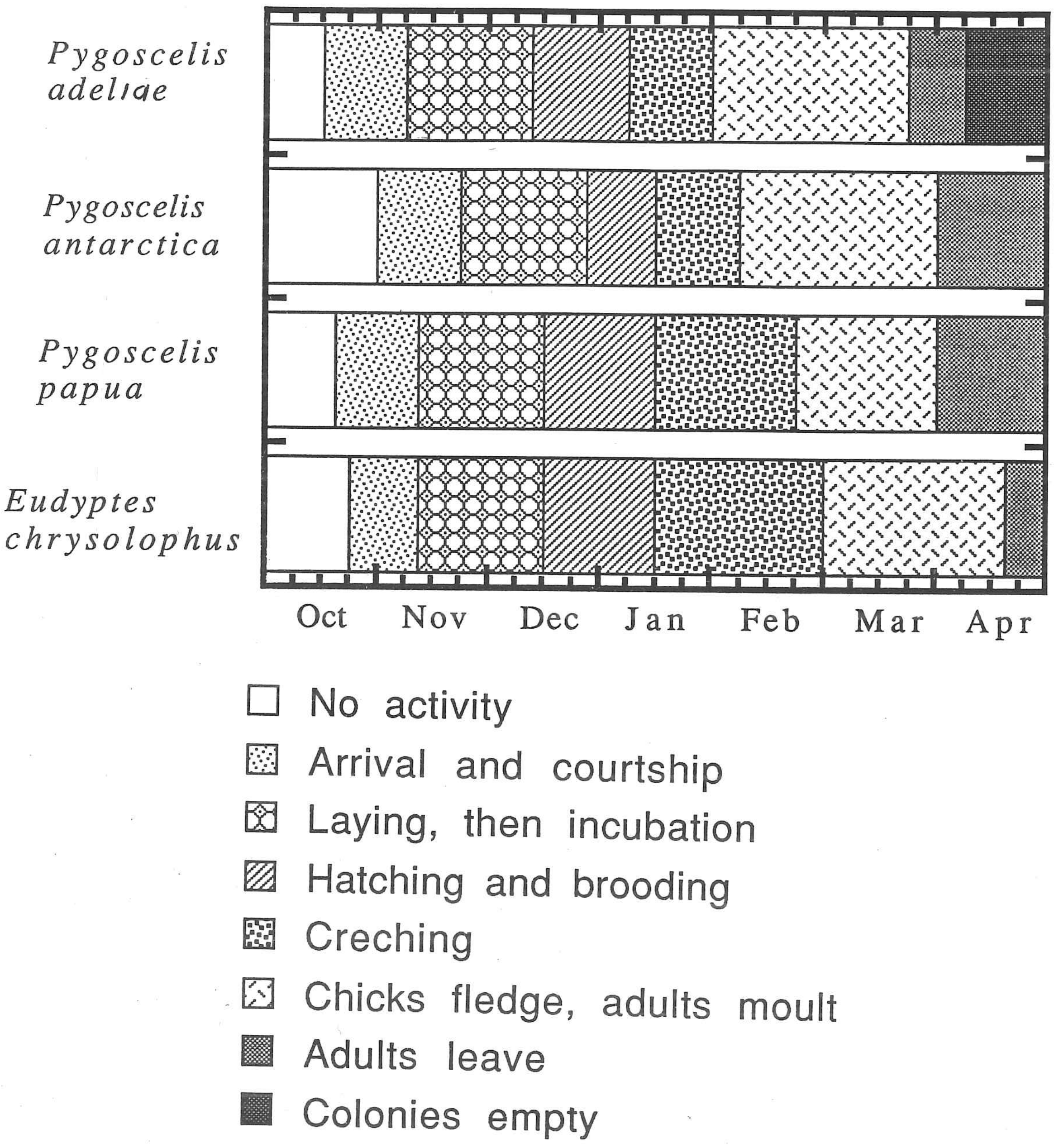



Figure 3. Approximate cycles of summer breeding Antarctic penguins (from Stonehouse, 1972; Muller-Schwarze, 1984; and Marchant and Higgins, 1990).

(Weimerskirsch et.al, 1992). Overall, however, adults and chicks of various stages and sizes are found ashore in the summer months, but this *melange* simplifies to chicks in creches and some adults over winter.

### 2.2: Penguin mob behaviour theory

The presence and behaviour of congeners also seems to be an important influence on an individual bird's behaviour on land. All Antarctic species congregate in large colonies, and are known to have a complex code of signals and vocalisations with which they specifically modify each other's social behaviour, for example, during courtship or agonistic interactions (Ainley, 1975; Spurr, 1975; Simpson, 1976, pp.124-125; Nelson, 1980, pp.97-99; Jouventin, 1982). Given that their breeding cycles are highly coordinated and synchronous within species - for example, all pygoscelid and macaroni eggs in a colony are laid within a few weeks of each other, those of the emperor, in a two to four week period (Stonehouse, 1972; Muller-Schwarze, 1984) - it would seem to be of benefit should congener behaviour aid hormonal factors in regulating the onset of each stage. From observations of captive Antarctic penguins, it has even been suggested that crowded conditions (i.e. the presence of many other birds) are prerequisites for successful breeding (Pankhurst, pers.comm.)[1].

Several biologists have commented that if any individual penguin begins moving "purposefully", others slavishly follow (Stonehouse, 1960, pp.55-56; Simpson, 1976, p.122; Robertson, 1990). Furthermore, Ackerman (1989) has

1, Sheila Pankhurst is a postgraduate student of the Zoology Department, University of Cambridge, and a former tourist in the Antarctic.

thus explained the misconception (used by Dawkins in *The Selfish Gene*, 1976, p. 6) that penguins on the ice edge push a sacrificial victim into the water to test for seals:

> Instead, what usually happens is that so many penguins are crowded onto an ice overhang that those near the edge get nudged off. When that occurs, the others plunge right in; they're very much creatures of the mob (p. 46).

Given the social nature of Antarctic penguin life, it is suggested that the behaviour of congeners provides potent stimuli which evoke, modify and reinforce much of the behaviour of the individual. The penguin mob behaviour theory (Appendix 3) will clarify some of the results discussed in the following chapter.

# CHAPTER THREE: EFFECTS OF AIRCRAFT ON PENGUIN BEHAVIOUR

The effects of aircraft represent the clearest and simplest form of human disturbance. Aircraft are obviously disruptive stimuli, and penguin reactions to them are often uncontentious - such as fleeing. From Culik et.al (1990) and Wilson et.al (1991) information is available on penguins at different stages of the breeding cycle, so it is possible to explore how breeding status affects response to aircraft, and how the implications of disturbance vary with breeding phases. Aircraft effects offer our best opportunity for understanding some of the basic issues in human disturbance, and are an appropriate place to start any comprehensive review of the field.

## 3.1: The basic penguin reaction to aircraft

Wilson et.al (1991) report that Adelie penguins commuting between the colonies and the sea exhibited a graded pattern of response to the approach of aircraft used in resupply operations at Esperanza, Antarctica. The initial response was to stop walking, then successively to walk, run and toboggan away from the source of disturbance. Birds which are not protecting young may respond more directly to a disturbing stimulus. Thus, this sequence may represent the basic penguin reaction to aircraft also adopted by juvenile non-breeding birds, and courting and moulting penguins with no immediate nest responsibilities. It possibly even represents the basic penguin reaction to all large, highly salient, fear-evoking stimuli. Kooyman and Mullins (1990) describe a similar sequence in emperor penguins "to any external disturbance" (p.174): neck craning, flapping of wings while standing in place, walking away from the disturbance, tobogganing away from the disturbance powered by feet, and tobogganing away at high speed powered by both feet and wings[1]. Penguins with eggs or small chicks sometimes respond with similar behaviours, but tolerate greater disruption before deserting their young (3.4; Appendix 3).

### 3.2: Reactions of penguins without eggs or small chicks to a single approach by aircraft

Wilson et.al (1991) observed commuting Adelies during a single approach by a Twin Otter, Super Puma helicopter, and C-130 Hercules, all travelling to a point 350m away at about the same speed. They found that the different aircraft produced different patterns of response (Figure 4).

The Twin Otter caused the birds to stop. This occurred when the plane was still 1 km away, but most birds did not begin moving away until it was 500m closer. Ten percent of commuters passed into the tobogganing stage as the Otter reached its closest distance, but this and other disturbance behaviour declined sharply as the aircraft receded and no disturbance was apparent once it had reached a distance of 600m. The Super Puma and the C-130 produced more extreme reactions. Although no effects were observed until the Puma was within 600m of birds, when it reached 400m all birds were moving away (percentage tobogganing could not be determined but Figure 3 indicates disturbance sufficiently severe to assume that it occurred). Approximately 35% of commuting Adelies began to move away when the C-130 was still 1.3 kilometres distant, and another 35% stopped moving. By the time the C-130 approached to 500m, all birds were moving away, and at its closest distance of 350m, 75% of birds were tobogganing.

1. However, the authors do not explain what stimuli caused these reactions or how they discovered this hierachy.

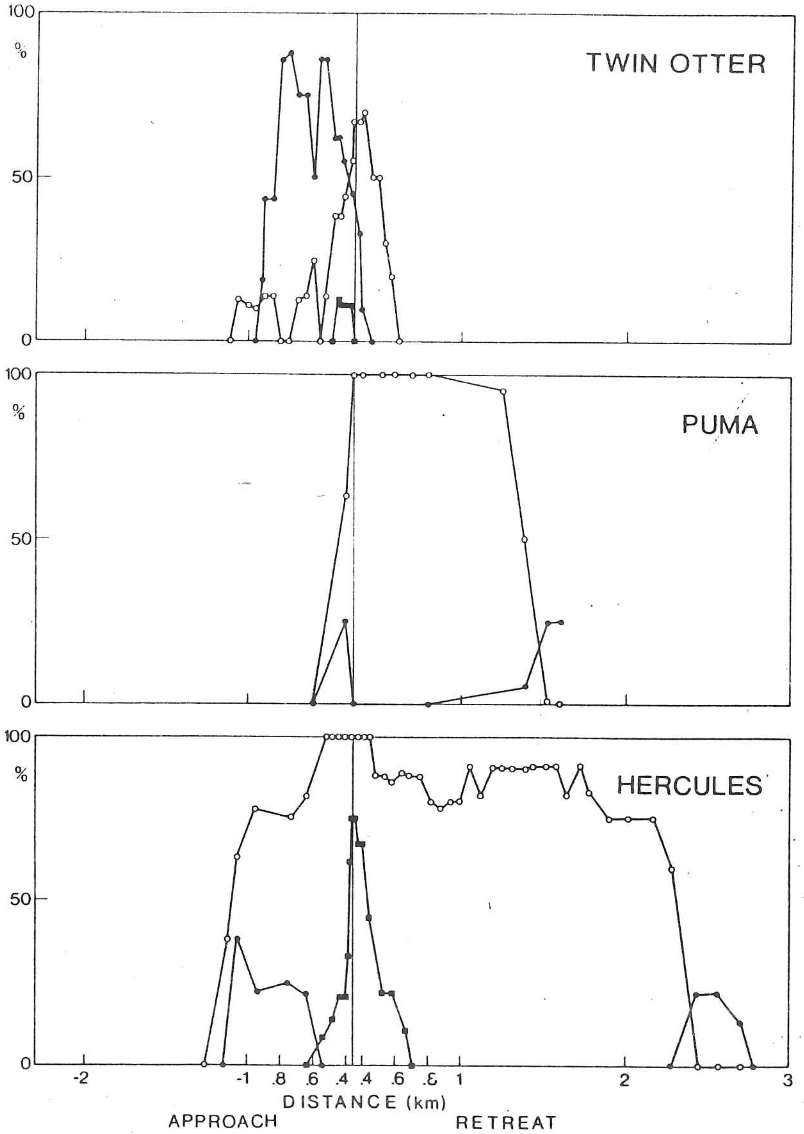



Figure 4. Patterns of commuting Adelie response to a single approach and departure by each of three different aircraft. Filled circles indicate the percentage of birds stopping movement, open circles indicate birds moving away from aircraft, and squares denote birds tobogganing away from the aircraft (Wilson et.al (1991), p.366).

| Type | Engine no. | Power (kw) | Wing/rotor span (m) | Length (m) | Max mass (kg) |
|---|---|---|---|---|---|
| MBB-BO 105 (Messerschmitt-Bölkow-Blom, FRG) | 2 | 275 | 9.3 | 7.8 | 1,750 |
| Super Puma AS 332 (Aerospatiale/ Westland, France, UK) | 2 | 955 | 15.0 | 18.8 | 6,400 |
| DHC-6 Twin Otter (De Haviland, Canada) | 2 | 425 | 19.8 | 15.1 | 4,760 |
| Lockheed C130 Hercules (Lockheed, USA) | 4 | 3,085 | 40.4 | 29.8 | 75,000 |

Table 1. Technical characteristics of aircraft commonly used in logistic operations in Antarctica (Wilson et.al (1991), p.365).

One of the most interesting aspects of these results is that reactions continued at high intensity as the aircraft moved off, increasing the distance between themselves and the penguins. Birds did not stop moving away from the helicopter until it had receded to 1.5km, and 50% were still moving away when the C-130 had receded to 2.3 km.

Wilson et.al (1991) comment that they could not ascertain whether the reaction subsided because of the disappearance of the stimulus or the post-stimulus time elapsed. Either of these alternatives would suggest a steady decline in response, and the former explanation would also entail a pattern of reduced responding symmetrical to that induced by the approaching aircraft. The Twin Otter pattern resembles this description, but response to Super Puma and Hercules seems to be path-dependent.

The penguin mob behaviour theory may help to explain these findings. Behaviour as the aircraft recedes seems to be strongly related to the percentage of penguins disturbed and the degree of that disturbance. Panicking penguins may have induced others to panic and, furthermore, the fact that so many birds were so highly disturbed probably reinforced the fear reaction. This explanation fits comfortably with the observation that commuting birds did not habituate during a subsequent three-day period of intensive helicopter activity (Wilson et.al, 1991). The birds do not get a chance to learn that the aircraft does not signify an impending attack as its appearance is firmly linked to a terrible event: congener panic. All that is necessary is that approach to some distance incite disturbance in a high proportion of birds, and that proportion of birds will do the rest. It is still a synergistic effect, however, as further increase in stimulus intensity (e.g. C-130 at 400m) augments the response, and stimulus removal eventually results in a return to an undisturbed state. Thus, the type of aircraft modifies the stimulus, and the behaviour of congeners confounds response.

The precise stimulus aspects which determine the differential response to types of aircraft are somewhat difficult to determine. Noise seems to be relevant; from Wilson et.al's (1991) table (Table 1) one can see that the Otter uses half as much power as the Puma, which uses less than one third as much power as the C-130. Yet, the exact role of noise as a general disturbance stimulus is difficult to assess. For example, there is no conclusive literature on the disturbance effects of trucks and construction vehicles. Wilson et.al (1990a) mention the "constant hum of machinery" (p.187) and the frequent passing of vehicles when discussing penguin population reduction induced by former operations at Cape Hallett, but many other stimuli were involved, including helicopter activity, and the presence of people. Similarly, Greenpeace International's report of activity at Dumont D'Urville (1990) describes "dust, noise and constant human activity" (p.51) confounded, and the impact on nearby birds is impossible to assess as scientists were actively trying to displace them.

Even so, noise seems to be important, at least when it is associated with something approaching in the sky, which in itself is probably disturbing as all land-based predators of penguins are flying birds. Another variable which distinguishes between the Otter and the Puma is the steady pattern of movement of one and the jerky movement of the other. If the reactions induced by the two aircraft could be compared to any reactions induced by the smaller MBB-BO 105 helicopter (Table 1), then some relationship between noise and movement might emerge. The great magnitude of disturbance caused by the C-130 is undoubtedly due to the extreme noise and size of the aircraft.

The first stage of the basic penguin response seems to be a sign of alertness which may be expressed as cessation of activity if the bird is not moving. One further implication of this analysis is that there is a great qualitative distinction between this response and the behaviour of moving away, as when the former was the predominant response the synergistic congener effect (Appendix 3) did not occur. There is also, then, a great qualitative distinction between response to the Twin Otter, which produced signs of alertness at its initial threshold, and the other two aircraft which immediately induced retreat behaviour.

**3.3: Reactions of penguins without eggs or small chicks to prolonged exposure to aircraft**

Wilson et.al's (1991) observations of commuting birds' reactions to a three-day period of Super Puma activity, and some of Culik et.al's (1990) comments on aircraft effects, indicate how learning processes during continuous aircraft activity may affect the basic reaction.

As Wilson et.al (1991, p.367) saw no evidence of habituation in commuting birds during those three days, we can assume that the reaction described in relation to the first approach by a Super Puma occurred in response to each flight. Similarly, Culik et.al (1990) also report that commuting Adelies did not habituate to helicopter operations, and "rushed" (p.180) away from a Sea King every time it approached. Yet, there is a great discrepancy between the distance at which Culik et.al's (1990) commuting penguins began to retreat in response to helicopter (1500m), and that at which Wilson et.al's (1991) penguins did likewise (600m). This might be explained by physical differences between the two aircraft, but a Sea King at 1500m probably looks smaller and is less noisy than a Super Puma at 600m. It is more likely that Culik et.al (1990) are describing penguins which had been exposed to this stimulus on several recent occasions. The combined effect of aircraft approach and congener panic is a potent consequence, the imminent occurrence of which is signalled by the appearance of the helicopter in the sky. Hence, through association learning, a previously neutral stimulus (helicopter at 1.5km) takes on disturbance evoking properties. This is supported by Culik et.al's (1990) observation that reaction began, not when the King started its engines 1500m away, but as soon as it rose to a height at which it could be seen.

The absence of the synergistic congener effect in relation to a Twin Otter means that prolonged exposure might result in habituation of response as the Otter passes time after time without causing much damage. A very different scenario is predicted for reaction to a large helicopter or C-130: disturbance reactions become manifest at an earlier stage of stimulus intrusion. In other words, the total amount of disturbance gets worse. This prediction is consonant with another of Wilson et.al's (1991) findings: the overall number of commuters decreased steadily over time. Whereas 3,125 penguins commuted between the colonies and sea on the day before helicopter activity, there were only 2,223 commuters on the second day of disturbance (71%), and 1,526 (49%) on the last day. Numbers rose to earlier levels the day after operations ended.

A few further aspects of disturbance emerged during the period of intensive helicopter activity.

It appears that birds feeding at sea were discouraged from returning to the colonies (Wilson et.al, 1991). Breeding Adelies ashore were brooding young chicks, which might starve if the relieving partner is delayed for several days (Davis and McCaffrey, 1986). However, the timing of partner relief is of crucial importance during the incubation phase of penguins whose partners take long foraging trips (Adelies, chinstraps, macaronis, kings and emperors; Davis and Speirs, 1990). Fasting incubating birds desert their nests when their stored energy is exhausted and their partners have not yet returned. Partners may miss each other by only a few hours, and eggs are snatched by skuas within seconds if left unprotected. At certain critical times, for example around the end of the Adelie's first incubation shift (Davis, 1991), there may be many birds running low on fat reserves. If the same helicopter operations were imposed on these species at such times, then induced delays in relief of any magnitude could lead to increased breeding failure.

The number of birds in the surveyed colonies decreased by more than 15% over the three day period, although former numbers were regained 24 hours later. An 8% decrease in active nests suggests that some of the birds that departed were tending chicks. The discrepancy suggests that some non-breeding birds also left the area. Wilson et.al (1991) suppose that the 8% mortality was the result of panicked birds fleeing their nests and exposing their chicks to skuas, but they offer no further description or explanation of this event.

### 3.4: Reactions of nesting penguins to aircraft

Wilson et.al (1991) found that, among nesting birds, the critical flight distance in relation to an approaching person increased with the size of the offspring. They suggest that the likelihood a penguin will flee its nest is inversely related to the chances of survival of the brood if left alone: while eggs or small chicks are almost immediately snatched by skuas, larger chicks are less frequently attacked. Culik et.al (1990) observed the same pattern in relation to aircraft approach. Adults with chicks at creche age fled in response to a helicopter overflight, but most incubating

Adelies remained on the nest when a Sea King flew over them at an altitude of 20m.

The problem here is that many report that large proportions of the incubating and brooding penguins in a rookery have fled in response to aircraft. Stonehouse (1965b) described scores of incubating and brooding Adelies deserting their young upon every landing of a helicopter (within 100m), up to five times a day. Muller-Schwarze saw "several thousand" incubating Adelies flee their nests, causing eggs to roll away, when a helicopter took off over the Cape Crozier rookery (Muller-Schwarze and Belanger, 1978, p.374). And Budd (1962) mentions that a Beaver aircraft circling over incubating emperors at 150m caused them to march away from the disturbance, a very serious intrusion given that eggs are incubated on the feet, and may roll out from under the brood pouch and freeze (Robertson, 1990).

One possible explanation lies in the duration of exposure. Whereas Culik et.al (1990) may be referring to a flight straight over the colony, taking off and circling overhead last longer, and a landing aircraft is a stimulus which does not go away. Rookery or colony size may also be important, for Culik et.al's birds were part of a group of only about 50 pairs, while Stonehouse (1965b) was dealing with some 1500 pairs. Perhaps a larger colony is more likely to contain individuals who, for whatever reason, are more prone to disturbance and induce others to react. Alternatively, slight signs of alarm may be quickly magnified in a ripple effect in a larger, more densely packed group, causing a reaction which would not occur in a small group if all birds showed little sign of concern. Nonetheless, Culik et.al's (1990) finding remains something of an anomaly.

One of Culik et.al's (1990) incubating Adelies and two of Wilson et.al's (1991) brooding Adelies were equipped with heart rate monitors during helicopter overflights. These individuals did not leave their nests, but the heart rate of the former increased from an average resting rate of 86 beats per minute (bpm) to a maximum of 150bpm, that of the latter from an average resting rate of 83bpm to a maximum value of 286bpm, accompanied by components of Ainley's (1975) quiet mutual display. These behavioural changes are not only indication of disturbance: dramatic heart rate increases may be cause for serious concern.

Although some have argued that stress-induced changes in heart rate are not accompanied by significant changes in energy expenditure (Owen, 1969; Culik et.al, 1991), others suggest that they are (Ferns et.al, 1979, p.599; Manser, pers.comm.[1]). Furthermore, Culik et.al (1990) chose to measure heart rate because Perry (1973) explained that it was a component of the fight or flight syndrome. Fight or flight can have a short-term but dramatic increase in heart rate and blood pressure, and a concomitant increase in metabolic rate (Moberg, 1985a, p.31).

Nest desertion during incubation may already account for about 15% of breeding failure in Adelies (Davis and McCaffrey, 1986). If a fasting bird is induced to burn its fat reserves more rapidly, then the chances of nest desertion increase. Even if heart rate increases to aircraft do not

1. Dr. Caroline Manser is in the Clinical Veterinary Medicine Department at University of Cambridge. She recently produced a detailed report on the identification and measurement of stress in animals for the RSPCA, an extract of which was published in *New Scientist, Vol. 134(1818)*: 34-36.

indicate increased metabolic rate, fasting penguins conserve their energy by reducing their physical activity, and probably, increasing their amount of sleep (Groscolas, 1990). Enormous heart rate changes and displays associated with a hesitancy to locomote (Ainley, 1975, p.512) are incompatabile with this strategy.

**3.5: Reactions of nesting penguins to prolonged exposure to aircraft**

The heart rates recorded by Wilson et.al (1991) appear to indicate that birds habituated to approach within 200m after three days of helicopter activity (Figure 5). Yet, by this time, penguins had been exposed to the aircraft for a total of 300-350 minutes. This may have delayed relieving partners for long enough to precipitate chick starvation (Davis and McCaffrey, 1986), thus accounting for part of the 8% breeding failure. This habituation might not have occurred had aircraft activity been more sporadic, and its effects may well only last for a short period of time: thus, we cannot conclude that habituation to helicopter achieved early in the season would still be apparent during later disturbance.

A bird on the nest which does not flee may well habituate, learning through repeated exposure that the aircraft is not going to attack. But the stimulus aspects of the aircraft may be inherently disturbing, which is likely if at least some of those stimuli are also presented by predators.

It is possible that Wilson et.al's (1991) birds did not habituate, but, instead, progressed from the fight or flight syndrome (characterised by increased heart rate) to the conservation-withdrawal mode of stress response (Moberg, 1985a). Apparently related to learned helplessness (Maier and Seligman, 1976), conservation-withdrawal occurs when an animal is unable to escape an aversive stimulus. It is a learned response which will take some time to appear. In contrast with the initial fight or flight

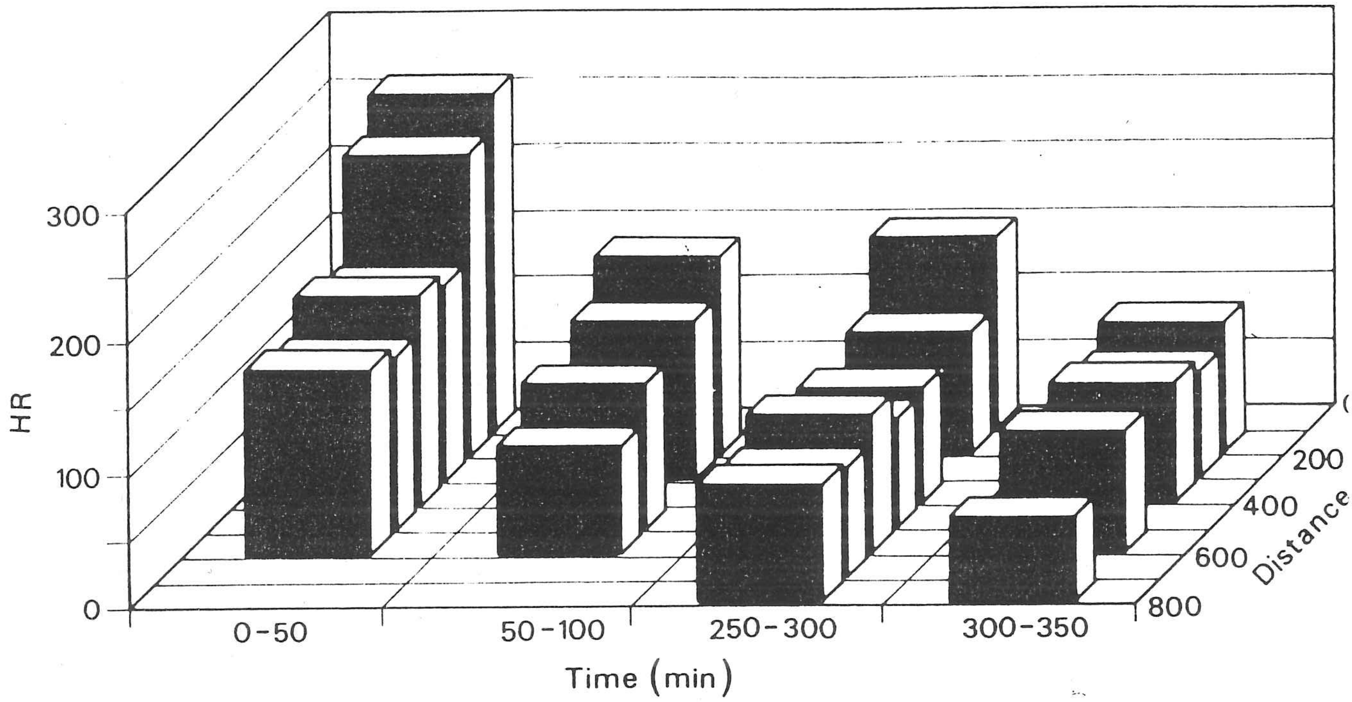



Figure 5. Heart rate (beats per minute) in nesting Adelie penguins as a function of duration of exposure (minutes) to a Super Puma helicopter (Wilson et.al (1991), p.367).

which mediates the choice between active responses (even if the presence of young prevents its expression), conservation-withdrawal is characterised by remaining motionless, a decrease in heart rate, and an increase in plasma corticosteroids. It is not clear whether helicopter disturbance endured longer than 350min, but heart rate figures after 300-350min exposure fall below the original resting pulse of 83bpm (Figure 5), and may have continued to go lower. A build up of plasma corticosteroids would certainly be related to the accelerated breakdown of body fat (Manser, pers. comm.). Thus, if penguins on the nest do develop the conservation-withdrawal syndrome, then they are expending their energy reserves more quickly.

### 3.6: Investigating a contemporary issue: king penguins stampede on Macquarie Island

The effects of aircraft on penguins at the creching stage received much attention recently when 1000 adult king penguins and 6000 creche age chicks were found dead on 11 June, 1990, at Lusitania Bay, Macquarie Island (Figures 6&7). Of an estimated 60,000 chicks and 5-10,000 adults ashore which could have been involved, these birds asphyxiated when their flight trapped them against a barrier of rock and tussock grass at the north-eastern end of the rookery (Royal Australasian Ornithologist's Union, 1990; Rounsevell and Binns, 1991; Figure 8).

On 30 May a C-130 made an airdrop to the station, then circumnavigated the island. Initially, both the Royal Australian Airforce (RAAF) which flew the C-130, and Macquarie Island zoologists were reluctant to connect the stampede with human interference (Anderson, 1990). This is understandable, given that a C-130 regularly makes an airdrop to the station three times a year. The Australian Federal Minister for Defence said that previous

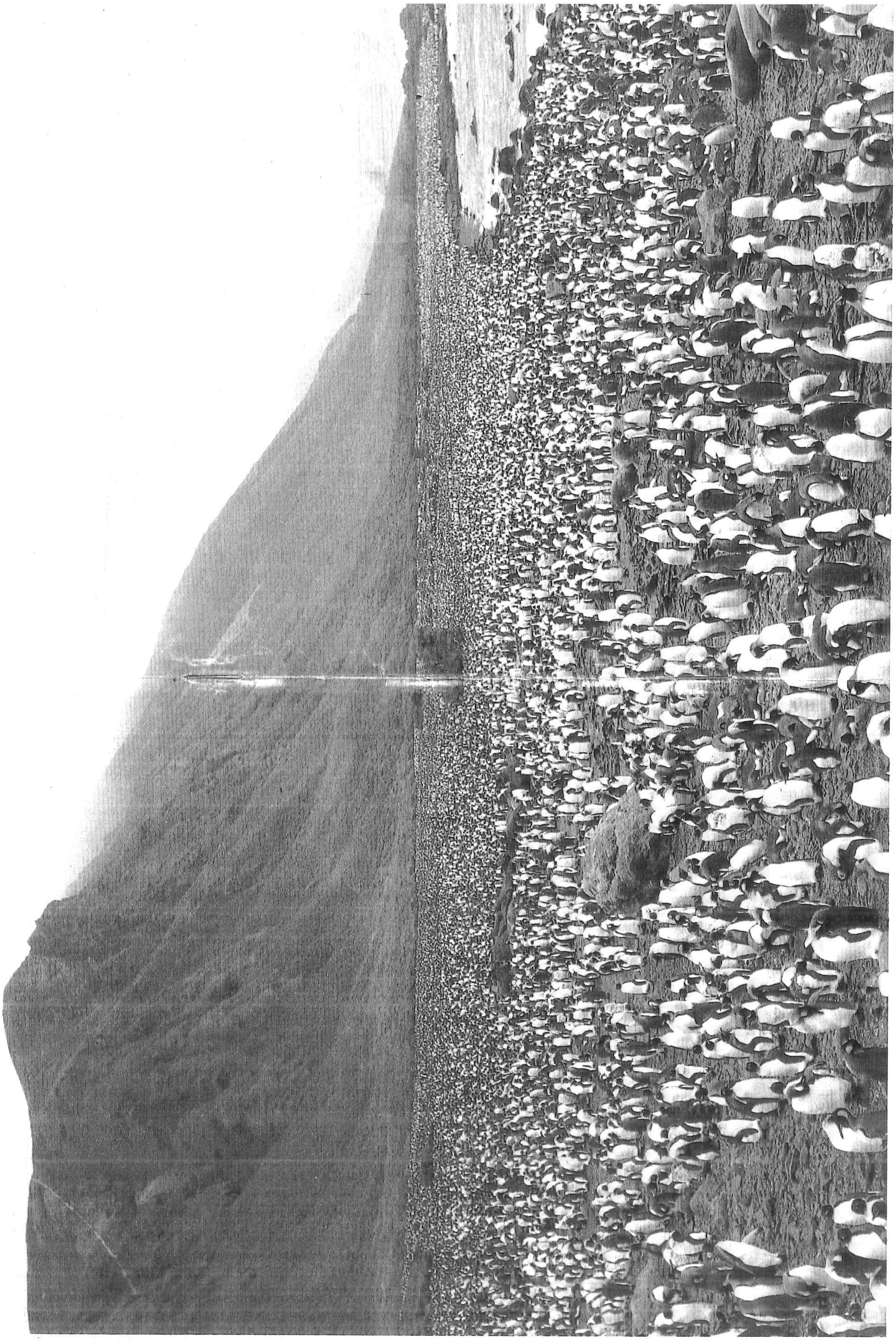


Figure 6. King penguin colony at Lusitania Bay, Macquarie Island (National Parks and Wildlife Service, 1987, front cover).

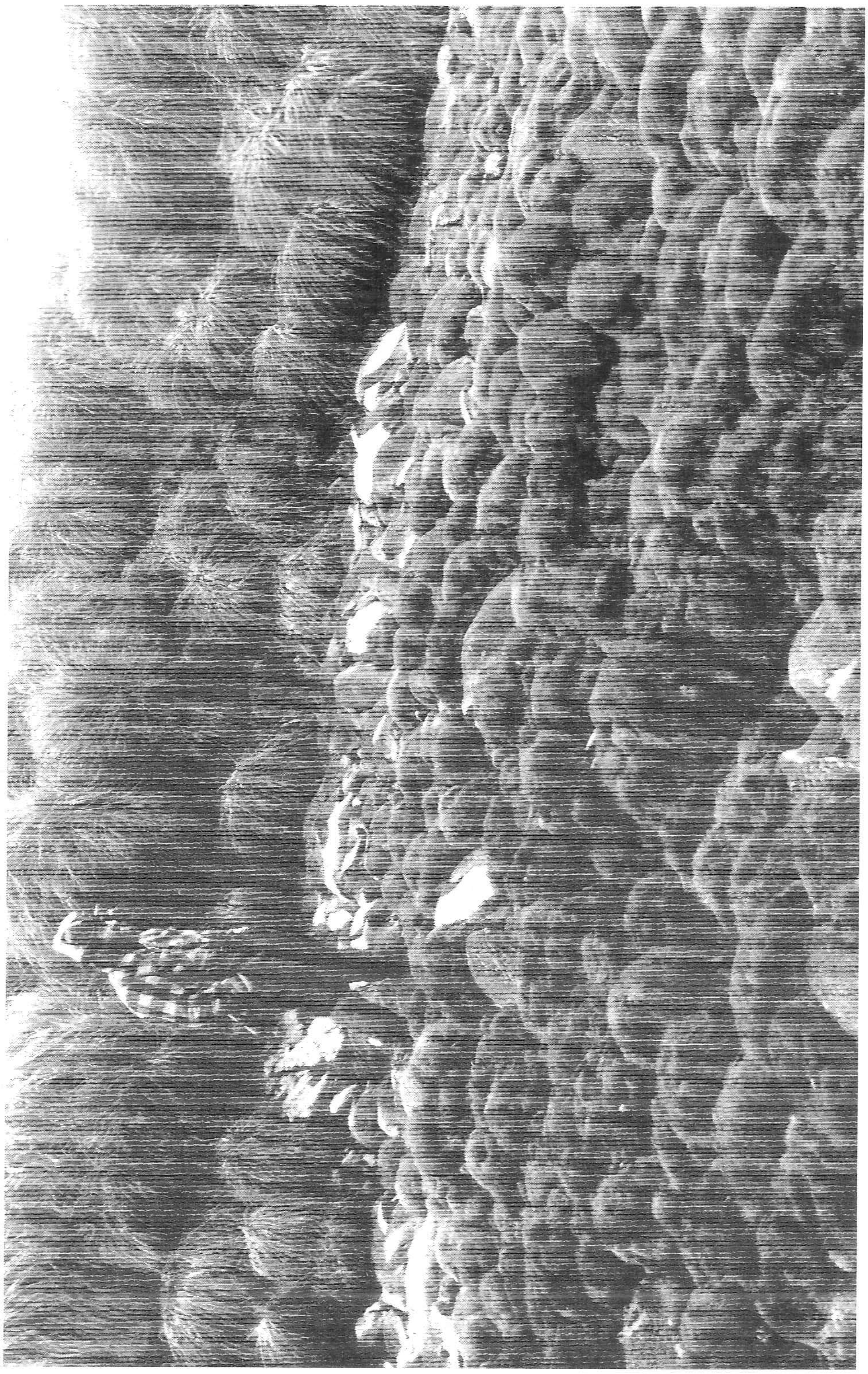


Figure 7. Dead king penguins following stampede at Lusitania Bay (Rounsevell and Binns (1991), p. 10).

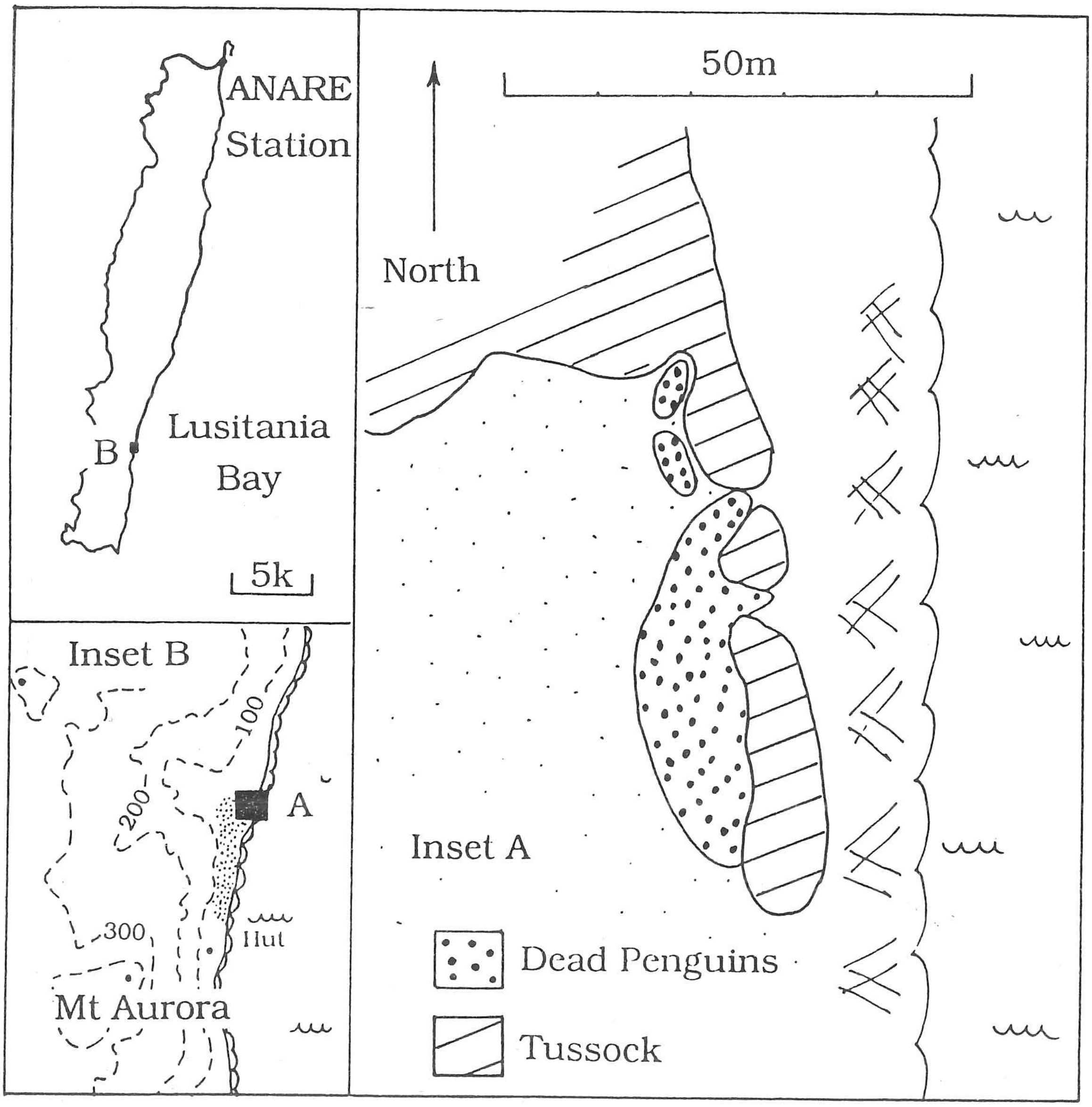



Figure 8. Macquarie Island, with Inset B, location of dead penguins at Lusitania Bay, and Inset A, how stampeding penguins were trapped against rock and tussock grass (Rounsevell and Binns (1991), p.9).

studies showed penguins were not normally alarmed by aircraft (Figure 9). Possible natural causes, such as seismological activity, were investigated, but a report by the Department of Parks, Wildlife and Heritage (responsible for Macquarie Island) concluded that the approach of a large aircraft at low altitude was the most likely explanation for the stampede. The report concluded, however, that on the evidence available it was not possible to attribute the stampede to any particular cause (Rounsevell and Binns, 1991).

The evidence presented here shows clearly that aircraft can have enormously disruptive effects on penguin colonies. Given further circumstantial evidence, it is very likely that the C-130 caused the stampede.

According to Smith (1989), the practice of circumnavigating the Island after a drop is not routine. Indeed, the C-130 generally circles in a clockwise direction around the peninsula, and from there can head for Australia (Figure 10). There is no apparent reason why an aircraft should fly around the island, unless for the sake of sightseeing. Even if the aircraft did remain "at least one nautical mile (1.85km)" (Figure 9) from the Bay, it was flying only 250m above sea level (Rounsevell and Binns, 1991). At this altitude, it cannot have been over the plateau (Figure 8), and was probably visible to the penguins. The aircraft travelled down the west coast and then up the east coast, and the direction in which the birds stampeded is consistent with them moving away from the plane. None of this can prove that the C-130 caused the penguins to stampede, and the death of 7,000 king penguins on Macquarie or other sub-Antarctic islands is without precedent in the absence of a natural catastrophy (Rounsevell and Binns,

# Inquiry rejects penguin death theory

A ROYAL Australian Air Force inquiry has dismissed claims that one of its aircraft caused the stampede which killed about 7000 king penguins on Macquarie Island in June.

The inquiry followed allegations from the Independent member for Denison in the House of Assembly, Dr Bob Brown.

Dr Brown suggested a Hercules supply plane may have caused or contributed to the stampede in which about 6000 chicks and 1000 adult penguins died.

The birds were found dead on June 11 at Lusitania Bay in the southern region of the sub-Antarctic island.

The Federal Minister for Defence, Senator Robert Ray, said yesterday the investigation found nothing unusual or unprecedented about the RAAF flight which approached the island in late May, about the time the penguins were thought to have died.

Senator Ray said crew testimonies indicated the aircraft remained well clear of known sensitive areas and at least one nautical mile from the bay.

Low-level flights around the island after air drops were normal practice.

Senator Ray said reports from aircrews in previous surveys and census studies of penguin colonies showed the penguins were not normally alarmed by aircraft.

But Greenpeace has blasted Senator Ray for shying away from a full public inquiry into the penguin deaths and said it was not satisfied the flight had not contributed to the deaths.

Figure 9. Inquiry rejects penguin death theory, from *The Mercury* (of Hobart), 19 July, 1990, p. 4.

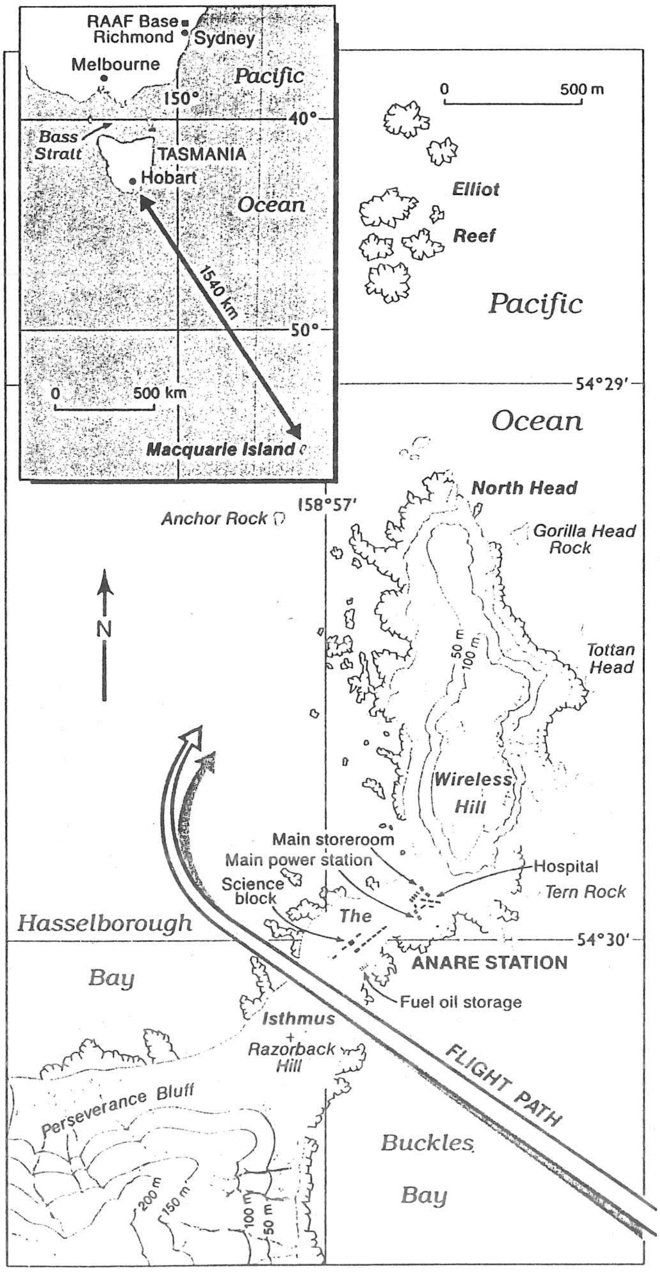



Figure 10. Usual flight path of C-130 over Macquarie Island peninsula before heading back to Australia (inset).

1991). But it is possible that such stampedes have occurred before, distressing, but not trapping and suffocating the birds.

### 3.7: Summary and implications

It is apparent that the stage of the breeding cycle influences the form and severity of aircraft disturbance response. Penguins without eggs or small chicks are free to react more directly to an aircraft stimulus than those which must protect young. On the other hand, the response of the former is also affected by that of congeners. The mob behaviour theory is a useful concept which may help to explain the synergistic congener effect at particular thresholds of disturbance and number of birds involved. The behaviour of congeners may also influence learning during repeated or prolonged exposure to aircraft. Where symptoms of the synergistic congener effect are seen, habituation seems unlikely to occur; indeed, subsequent exposure may augment the overall degree of disturbance.

Penguin response to aircraft will vary not only with such situational variables, but with changes in aspects of the stimulus. The broadest division of these is that between types of aircraft. The finding that a Twin Otter induces less disturbance than a C-130 or large helicopter concurs with comments in the literature (e.g. Sladen and LeResche, 1970, p.590); level or quality of noise, or pattern of movement may be implicated, but their relative significance is unknown.

Based on the experiments of their team, Wilson et.al (1991, p.369) have provided recommendations (Appendix 7), several of which (1, 5, 7) are attempts to limit aircraft disturbance.

They suggest that aircraft activity should be carried out after chicks have fledged. Recognising that resupply of bases may be logistically impractical at such a late stage, the alternative suggested is during incubation, when birds have been incubating for at least 10 days. Ten days into the incubation phase of Adelies is approaching the end of the first incubation shift, a very vulnerable phase of the breeding cycle (Davis, 1991). Even small delays in the return of birds at sea may be significant at this time, and inducement of accelerated energy burning could lead to breeding failure in individuals of species which must ration fat supplies during a long and demanding fast. Aircraft activity may cause both phenomena.

On the other hand, their preferred period might be more vulnerable than incubation. The moulting adults which are present after chicks fledge also fast, for the temporary reduction in their insulation does not allow them to maintain thermal balance in water (Groscolas, 1990, p.269). They are even more likely than incubating birds to be induced into using their energy supplies faster than usual, as in the absence of young to protect, they are likely to run before a helicopter or C-130. According to the arguments above, if, for example, a C-130 were to approach to 400m several times over a short period, the results could be disastrous. Birds would experience great heart rate changes, many of them would run, and they would soon come to respond when the aircraft were much further away.

The occurrence of mixed species colonies (e.g. gentoos, chinstraps and Adelies) will probably confound all of the reaction processes suggested here. Different species may have different response thresholds which would complicate the synergistic congener effect. Also, the species present may be at different stages of breeding (Trivelpiece et.al, 1987), making it impossible to confine disturbance to one stage of the cycle.

Thus, it is not yet, if ever, possible to define a "safe" period for aircraft activity during Antarctic penguin breeding, particularly a standard safe period regardless of the configuration of all of the above variables. Wilson et.al's (1991) recommendations five and seven are of the form most suited to the current state of knowledge (and are reminiscent of earlier guidelines, 1.3(a)): keep aircraft activity well away from penguins. A distance of one kilometre may not be sufficient to prevent disturbance, for the king penguin stampede might have been caused by a C-130 at such a distance. However, it provides a starting point which could be adopted prior to further careful observations.

### 3.8: Advice to scientists

Flights over or close to penguin colonies are also made for aerial photography, an accurate method of census in which photographs are later examined with magnifying equipment. The most effective time to photograph an Adelie rookery is during early incubation, when 70-90% of birds ashore are incubating eggs and birds are evenly spaced (Stonehouse, 1969, Taylor et.al, 1990); incubation shifts of macaroni penguins may be similarly appropriate. Sladen and LeResche (1970) recommend that ideal conditions involve the use of a 305mm lens in a Twin Otter flying at 610-762m. If, in accordance with the *Protocol*, aerial census can be planned to coincide with a stage of incubation which would not delay birds returning from sea, then a few isolated passes at a high altitude in a Twin Otter will probably create little disturbance. Researchers could aid the cause by employing ground-based observers to record responses among birds.

The different breeding cycle of the emperor means that summer photography may be both inaccurate and dangerous. Kooyman and Mullins (1990) recommendation that a single overflight in a LC-130 during emperor creching would be safe is not supported here, and their suggestion to experiment

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The different breeding cycle of the emperor means that summer photography may be both inaccurate and dangerous. Kooyman and Mullins (1990) recommendation that a single overflight in a LC-130 during emperor creching would be safe is not supported here, and their suggestion to experiment with altitude thresholds is not acceptable. If emperor research can be undertaken over winter, Robertson's (1990) method of floating a remotely controlled, camera equipped helium balloon over incubating emperors seems a most suitable method. He does not mention birds' reactions, but it is very likely that they can tell the difference between the movement patterns of balloons and skuas. Unfortunately, in relation to both disturbance and research, such clearly defined periods do not occur in the cycles of other pygoscelids, or king penguins.

# CHAPTER FOUR: PRESENCE AND BEHAVIOUR OF HUMANS - APPROACH AND HANDLING

Reports of aircraft approach to penguins tend to mention the type of craft and the altitude. In contrast, details are rare in accounts of penguin response to humans, and disturbance effects are often only noted in cases of breeding failure. From the broad descriptions used in reports one must attempt to deduce the specific components of interactional processes.

## 4.1: An apparent contradiction between experiments and experience

A belief commonly expressed in both official and popular sources is that Antarctic penguins are tame and unafraid of people (Halle, 1973; SCAR, 1984; Porter, 1988, p.47; Ackerman, 1989; Heap, 1990, p.2603). This is said to be the result of millions of years of evolution without land-based predators. Reports of some of the very first encounters with penguins support this assertion. Scott wrote of the Adelies at Cape Evans:

> They waddle forward, poking their heads to and fro in their usual absurd way, in spite of a string of howling dogs straining to get at them...The dogs make a rush as far as their leashes or harness allow. The penguins are not daunted in the least...and then the final fatal steps forward are taken and they come within reach. There is a spring, a squawk, a horrid red patch on the snow, and the incident is closed. Nothing can stop these silly birds. Members of our party rush to head them off, only to be met with evasions (1968, p.72).

This is another example of penguins following those ahead of them, apparently not learning from the consequences of others' behaviour. Yet, at least the first birds to approach seem to have been curious about the new arrivals. Many who have been to the Antarctic have tales which similarly tell of penguins approaching them (Dunn, pers. comm.[1]), "running up to"

1. Mike Dunn is an adventure tour leader who has worked for a variety of companies, such as Society Expeditions and Adventure Network, and has travelled in the Antarctic over a period of 13 years.

them (Halle, 1973, p.60), "surrounding" them (Cahill, 1992, p.94), and "studying" them (Ackerman, 1989, p.39).

Culik et.al (1990) and Wilson et.al (1991) report dramatically different reactions in Adelies at Esperanza. Both papers cite striking heart rate (HR) increases in nesting birds to approach by a single human from over 30m away to within a few metres (86bpm to 127 bpm, and 76bpm to 135bpm, respectively). Wilson et.al (1991) found that intermittant activity by one person about 20m away caused commuting Adelies to deviate by 70m from their usual path, an effect which was still apparent four hours after the person left. Culik and Wilson (1991) state that the presence of people adversely affects breeding penguins no matter how well behaved such persons may be (Appendix 2). What can be concluded about the effects of people's behaviour on penguin behaviour? The reconciliation of such disparate reports can only be achieved through reassessment of published data.

**4.2: Reassessment of some reports - preliminary suggestions about stimuli in people's behaviour and aspects of penguin response**

It appears that close approach and physical interference with breeding Adelies over several seasons reduces breeding success. In 1971, Oelke (1975) found that the percentage of chicks fledged from eggs in study groups on a transect between two huts at Cape Crozier was significantly less than that of groups several hundred metres away (Figure 11, Table 2). Activities over previous seasons included regular helicopter landings around the station hut and a great number of scientific studies. The latter involved handling and a variety of other intrusive procedures (e.g. attachment of electrocardiogram, Sladen et.al, 1966a; Boyd et.al, 1967; sexing by internal examination, and intensive banding, Sladen et.al, 1966b; Wood et.al, 1967; Sladen et.al, 1968a; and stomach pumping, Emison, 1968).

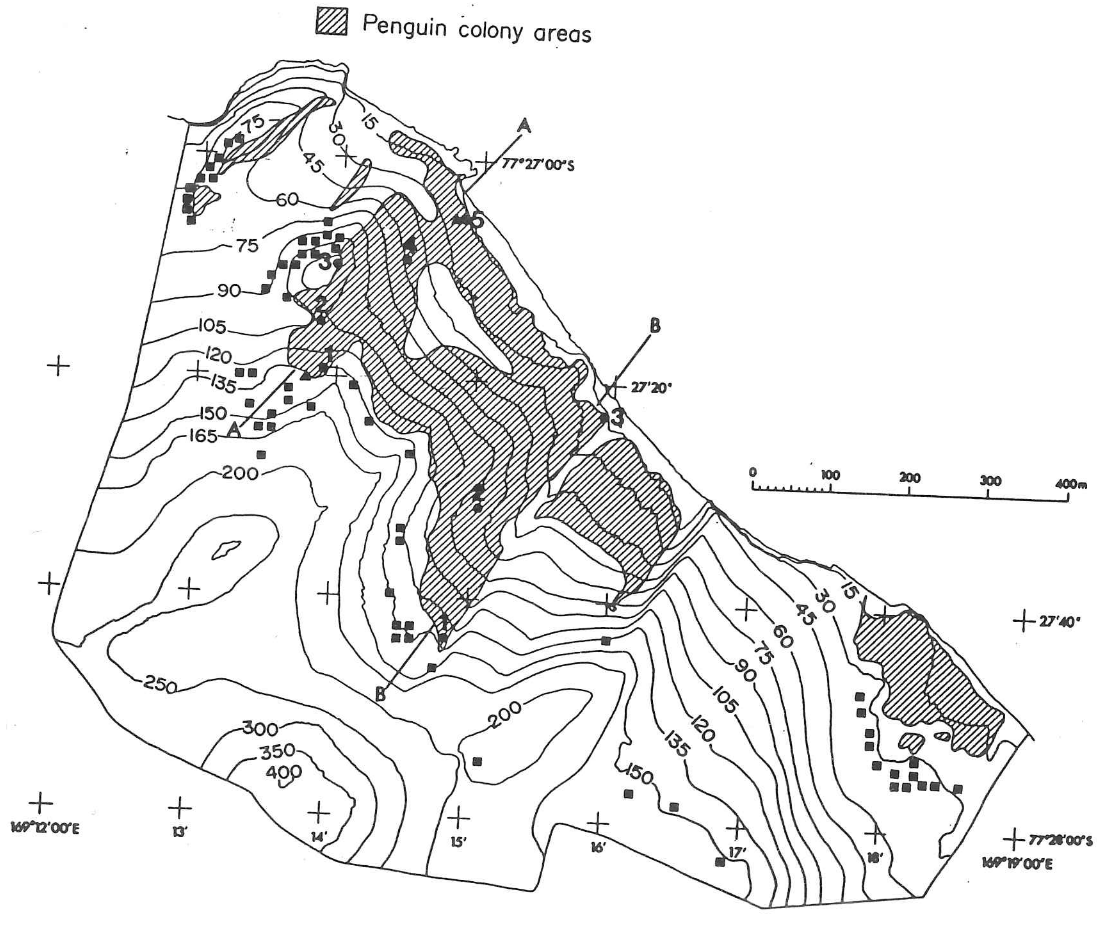


Figure 11. Adelie penguin colony at Cape Crozier. Abbreviations AA and BB mark sites of transects, and numbers along transects indicate breeding groups A1-A5, and B1-B3. Triangles near A1, A5 indicate huts, that near A1 is the station hut (Oelke (1975), p. 365).

| Study area (number) | Eggs/pair (27.11.70) | Hatched chicks per pair | Chicks in crèches (4.1.71) | Chicks before leaving natal site |
|---|---|---|---|---|
| A1 | 1.91 | 1.62 | 0.87 | 0.57 |
| 2 | 1.64 | 0.77 | 0.65 | 0.06 |
| 3 | 1.86 | 1.70 | 1.00 | 0.44 |
| 4 | 1.80 | 1.45 | 1.10 | 0.87 |
| 5 | 1.85 | 1.60 | 1.28 | 0.68 |
| B1 | 1.95 | 1.68 | 1.36 | 0.75 |
| 2 | 1.78 | 1.53 | 1.32 | 1.20 |
| 3 | 1.83 | 1.26 | 1.00 | 0.85 |

Table 2. Egg laying, hatching, and number of young fledged per breeding pair in transect A and B, Cape Crozier. No significant differences exist at the creche stage, but breeding success of transect A was lower than that of transect B ( = 5.69, *df*=1, $p<0.025$), even when excluding the totally unsuccessful breeding group A2 from the computation (Oelke (1975), p. 376).

One might argue that the disruptive effects of aircraft alone are great enough to explain the discrepancy; certainly Ainley et.al (1983, p.174), working in the same area, were reluctant to blame declining productivity around the station hut on anything other than helicopter landings and removal of birds for experiments. However, examination of the data reveals that group A4 was no less successful than groups in transect B. Groups A4 and A5 are the most remote from helicopter landing and activity, presuming that helicopters approached from a south westerly direction, the direction of McMurdo Base (Figure 12). Group A5 is right next to one of the huts. For studies such as assessment of diet and biotelemetry of temperature there is no reason not to use the closest birds, and A5 had probably been involved in past experiments. It appears likely, then, that exposure to people and intrusive procedures detrimentally affected the breeding success of A5.

Helicopter activity exerts severe effects on penguins, including fleeing of adults and consequent predation on chicks, and the influence of past activities on groups A1-A3 was probably at least partially due to long-lasting changes in factors such as group composition. But reactions to interference by people on foot are not as dramatic - even a bird removed from a nest may resume incubation if its eggs have been protected (Wilson et.al, 1991). How did previous human manipulations induce low breeding success in A5?

This low breeding success was measured by another person. Oelke (1975) tried not to disrupt his subjects, sitting quietly, each time in the same spot 10-15m away, although handling and weighing birds at intervals. Nonetheless, his mere presence may have been an anxiety evoking stimulus by virtue of penguins' past experience with people. Perhaps Oelke was

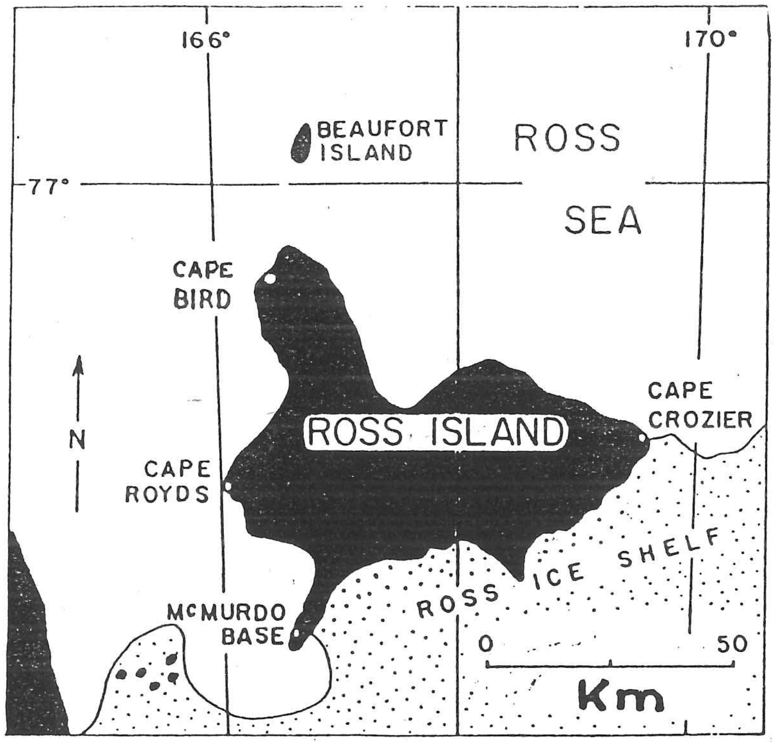


**Figure 12.** Location of Cape Crozier rookery in relation to McMurdo Base (Ainley et. al (1983), p. 9).

| | 1980–81 | | | | 1981–82 | | | |
|---|---|---|---|---|---|---|---|---|
| | Study sample | | Control colony | % decrease in study colony | Study sample | | Control colony | % decrease in study colon |
| | actual | adjusted[1] | | | actual | adjusted | | |
| Adélie | | | | | | | | |
| Pairs[2] *n* | 60 | 60 | 394 | | 27 | 26 | 456 | |
| Eggs *n* | 120 | 120 | 788 | | 49 | 43 | 754 | |
| Chicks *n* | 98 | 80 | 647 | | 35 | 27 | 612 | |
| % Eggs hatched | 82 | 67 | 82 | 15 | 71 | 63 | 81 | 18 |
| Chicks hatched/pair | 1·6 | 1·3 | 1·6 | | 1·3 | 1·0 | 1·3 | |
| Chicks fledged *n* | 9 | 9 | 303 | | 11 | 13 | 578 | |
| % Chicks fledged | 9·2 | 11·3 | 46·8 | | 31·4 | 48·1 | 94·4 | |
| Chicks fledged/pair | 0·15 | 0·15 | 0·77 | | 0·41 | 0·48 | 1·27 | |
| % Chicks/egg | 7·5 | 7·5 | 38·5 | 31 | 22·4 | 30·2 | 76·7 | 46·5 |
| Chinstrap | | | | | | | | |
| Pairs *n* | 60 | 46 | 294 | | 64 | 55 | 343 | |
| Eggs *n* | 105 | 85 | 543 | | 123 | 103 | 642 | |
| Chicks *n* | 39 | 6 | 106 | | 55 | 38 | 431 | |
| % Eggs hatched | 37 | 7 | 20 | 13 | 45 | 37 | 67 | 30 |
| Chicks hatched/pair | 0·6 | 0·1 | 0·5 | | 0·9 | 0·7 | 1·3 | |
| Chicks fledged *n* | 1 | 1 | 13 | | 23 | 23 | 262 | |
| % Chicks fledged | 2·6 | 16·7 | 15·1 | | 41·8 | 60·5 | 60·8 | |
| Chicks fledged/pair | 0·016 | 0·02 | 0·04 | | 0·36 | 0·42 | 0·76 | |
| % Chicks/egg | 1·0 | 1·2 | 2·4 | 1·2 | 18·7 | 22·3 | 40·8 | 18·5 |

**Table 3.** Breeding success in Adelies and chinstraps in Lishman's (1985) study and control colonies, 1980/81 and 1981/82 (p. 91).

unwittingly causing the low breeding success, his periodic physical interference only serving to confirm the birds' association that he was, indeed, one of *those* creatures.

If Oelke's handling affected birds which had already undergone learning experiences with people, it is undetermined whether his intrusions affected naive birds. He reports no significant difference between the number of chicks per pair in his total study group and those in groups drawn at random from the rookery. However, this comparison was made with counts from the very beginning of creching (pp. 387, 390): The difference between groups on transects A and B was not apparent at this stage, and did not become significant until chicks were fledging (Table 2).

Lishman (1985) reported that daily visits and regular handling of eggs and chicks in Adelie and chinstrap colonies severely affected breeding. Adelies hatched 15% fewer eggs, fledging 31% fewer chicks, and chinstraps hatched 13% fewer eggs, fledging 1.2% fewer chicks compared with control groups visited only three times (Table 3). These effects became dramatically worse when Lishman repeated his activities the following season, probably causing disturbance by virture of both past association and present action. In the second season Adelies hatched 18% fewer eggs, fledging 47% fewer chicks, and chinstraps hatched 30% fewer eggs, fledging 19% fewer chicks than control groups.

Handling of nesting birds or their offspring may, therefore, produce a reaction which results in lowered breeding success. It seems that something unique about these stimuli causes a learning process which may endure over seasons and by which, as with the synergistic congener effect, response amplifies with greater exposure.

However, research by van Heezik and Seddon (1990) on African penguins *Spheniscus demersus* indicates that the presence of people does not always have the same stimulus value. The reactions of the birds they studied are highly relevant to those of Antarctic penguins. They worked on Dassen Island, a nature reserve run by one warden where unauthorized landings are prohibited, so birds were unlikely to have been exposed to many people. Penguins in warmer latitudes living amongst vegetation tend to be more 'flighty', disappearing into undergrowth or bushes (Stonehouse, pers. comm.), which Antarctic penguins cannot do, and as moulting or resting groups on the beach (i.e. penguins without chicks), their subjects had little reason to not flee if sufficiently provoked. They found that the very gradual approach of one person from 70m to 10m, stopping at 10m intervals for two minutes, induced few penguins to move away. The predominant response was alert or agitated behaviour and cessation of pre-stimulus lying and resting.

Furthermore, these responses were amenable to habituation. Groups approached to 10m twice daily over three months showed the lowest ratio of alert/agitated to normal behaviour, followed by a group which had been in the vicinity of daily human activity. Three groups on other parts of the island, far from human activity, showed the highest incidence of alert/agitated behaviour, as is to be expected to the appearance of a novel stimulus at close range, in the absence of prior experience to indicate its innocuity.

The specific responses which resulted in lowered breeding success in Oelke's (1975) and Lishman's (1985) birds cannot be identified from these reports. However, one can deduce that scientists' activities had a strong effect on their subjects, whereas van Heezik and Seddon's (1990) penguins seem only mildly disturbed. Thus, to an Antarctic penguin, human approach to a certain distance may well be a stimulus totally different from, and much less disturbing than, handling.

**4.3: The human approach model: A proposed explanation of Antarctic penguin interpretation of human behaviour**

Let us begin with one penguin and assume that it has not seen a person before. The person is 20 to 30 metres away. The bird has no stimulus template for this person. It corresponds to nothing in the bird's experience. Leopard seals, the penguin's main predator, rarely attack on land where penguins may wander quite close to them (Halle, 1973). Their only terrestrial predators are flying birds which mainly attack small chicks and eggs, so an adult penguin without young should have no cause for alarm. At this distance, the person will probably appear small, perhaps about the size of another penguin, although it may be obviously different, given its pattern of movement or its colouring. Some birds might approach to investigate, and finding an object which is big but does not appear harmful, they may lose interest. Perhaps much of what visitors find so endearing is actually displacement behaviour - such as the Adelies which ran up to Halle (1973), sometimes running away again, sometimes falling asleep on the spot. His description of such birds echoes this interpretation: "It may seem at a loss to know what to do next" (p.60).

Thus, a mobile penguin may be prompted into action, but nesting birds are likely to be affected too. Having discerned the new stimulus, a nesting penguin probably experiences a HR increase. This is not an automatic sign of undue stress, merely an indication of general arousal, which occurred in domestic hens in response to any change in stimulus conditions, including the delivery of food (Jones et.al, 1981). Another response to a new and possibly threatening situation is the cessation of activity. This is a common initial sign of fear (Manser, 1992), and as described above (3.1, 3.2, 4.2), seems to indicate alertness or mild apprehension in penguins. These responses represent disturbance but are likely to be amenable to habituation as repeated exposure indicates that this unusual stimulus is harmless.

As the person starts to approach the stimulus configuration changes. The object appears to increase in size. The closing distance between bird and human is very different from that ensuing from a penguin approaching a person. Lack of control over surroundings is anxiety inducing in animals and, under extreme conditions, can lead to maladaptive conditions such as learned helplessness (Maier and Seligman, 1976). At some distance, the human will cease to be a neutral or mildly worrying stimulus and, by virtue of its approach and closeness, become threatening. This point (the danger threshold distance-DTD; Appendix 3) should be identifiable by an increment or change in response. Wilson et.al (1991) have identified some relevant behavioural changes. They approached 35 birds (which they had not previously approached) at various stages of the breeding cycle and found mean critical distances at which birds would flee: 6.1m for birds with large chicks, 1.3m for birds with small chicks, and 0.3m for those with eggs. As they argue, the critical distance seems to be inversely related to the brood's chances of survival if left alone. Thus, the discrepancies between these behaviour thresholds probably represent the bird's cost-benefit analysis of its investment versus the threat to itself. This corroborates an earlier comment by Sladen (1956) that newly arrived Antarctic penguins are more likely to flee nest sites in response to close approach, whereas a bird which has built its nest and established a territory will stand and fight.

Direct approach (i.e. without pauses) seems to evoke a different reaction from gradual approach. Whereas few of van Heezik and Seddon's (1990) birds moved away in response to the latter procedure, approach at a slow but steady pace could induce departure in up to 75% of a group. A steadily approaching unknown stimulus gets bigger and closer much more quickly, which is more threatening as the animal has less time to react. Indeed, increases in speed of approach can lead to an earlier, more drawn out and more extreme heart rate change in herring gulls *Larus argentatus* (Ball and Amlaner, 1979) and Adelie penguins (Culik et.al, 1990). Murphy has suggested that penguins are not capable of rapid visual adjustment (Sladen, 1956, p.43); if true, this makes it all the more likely that they would react dramatically to a rapidly approaching unknown object. That the speed is the key variable rather than anything inherent about humans is supported by the fact that the effect of van Heezik and Seddon's (1990) direct approach was only mildly curtailed by previous innocuous exposure to people: 75% of birds in the group regularly visited were still induced to flee, but just at lesser distances than naive groups.

Once the person is sufficiently close, it may begin to handle the nesting penguin. A wealth of evidence supports the above assertion that handling is a stimulus distinctly different from other human behaviour. Oelke (1975, p.378) stopped trying to weigh Adelie chicks because of the "severe disturbances" which this activity produced. Piatt et.al (1990) found that fledging success of least auklet *Aethia pusilla* chicks was significantly reduced in nests in which chicks were measured every few days. From 16 plots of 200m$^2$ each, 38% of the chicks that died or disappeared were those they had handled. Hughes and Black (1976) report that domestic fowl produced the fight or flight response when picked up, some birds attacking the handler, others trying to flee. Even in these birds presumably used to the presence of people, handling produced strong responses in those unaccustomed to it. After two days of being caught in a group, held for a few seconds, and then returned to the cage, egg production decreased by 10.6% and deformations were evident in the shells of eggs laid. These deformations even appeared in the eggs of birds accustomed to handling, the result of stress-induced shell gland contraction at a stage of egg formation when calcification is not yet so advanced as to withstand muscular pressure.

To pick up or remove an egg or chick is, to an Antarctic penguin, established predator behaviour. Picking up an adult is life-threatening and, therefore, also predator behaviour, which is all the more distressing for being a threat not previously experienced on land. Because of this lack of precedent, threatening behaviour by the new, large predator will have particularly rapid and long-lasting learning effects[1], influencing subsequent response to human behaviour (Appendix 3).

The potentially serious nature of response to this predator behaviour is illustrated by Boyd and Sladen (1971) who monitored changes in internal temperature following handling. Unlike HR increase, temperature increase is not an immediate response of the autonomic nervous system; it involves more metabolic processes and takes longer to become apparent. However, a penguin exhibiting increased temperature is definitely burning more energy. This is a clear sign of detriment to the health of a fasting penguin.

1. This phenomenon is known as one trial learning. An analagous situation occurs when a person is put off aeroplane trips for life because his or her first flight comes close to disaster.

Boyd and Sladen (1971) captured incubating Adelies and chicks and implanted telemetric devices in their abdominal cavities. Such implants may well be painful after recovery from the operation (Manser, pers.comm.). Thus, capture, removal, and replacement in an unwell state (or so it may feel to the bird) constitute the first learning experience with humans.

It is surprising that one such individual showed no measured physiological change to further approach and tail lift, but individuals will vary in response. Another adult was "visibly disturbed" (p.373) by the capture of a bird two metres away, and its temperature increased by 0.4°C. Unlike the penguins described by Scott (1968), this individual had first hand experience of the predator, and may have been anticipating capture. Heise (1989) reports that HR of mallard duck *Anas platyrhynchos* was always higher during human approach than retreat, and Hughes and Black (1976) mention signs of agitation in hens in the line to be handled next, which were not apparent in those already handled. The greatest effect was produced in an adult which was twice handled for weighing in a 30 minute period: its temperature increased by 1.2°C and averaged 1°C higher than before handling for the next four hours.

**4.4: Application of the human approach model to initial contradiction.**

Let us reassess the conclusions of Culik et.al (1990) and Wilson et.al (1991). Culik et.al (1990) took an incubating Adelie from its nest. Protecting its eggs, they handled it for 10 minutes, attached an electrocardiogram (ECG) with safety pins and wires, and then released it to return to its nest. Its heart rate was "high" (p.178), decreasing to a steady level within 60-90 minutes. Once one experiment was completed, they removed the ECG and attached it to another penguin, repeating this process to involve five incubating adults in a colony of approximately 50 pairs. Within 24 hours of each manipulation, a single person approached the penguin. In fact, it appears that nine approaches in all were made to the five birds (p. 179), so four animals experienced two approaches in 24 hours. The second approach was probably more anxiety-inducing than the first, given that all animals had by then experienced the person as a predator, some had been subjected to it coming close and interfering with neighbours, and all had experienced another direct approach. The average of results obtained showed that by the time the person stopped three metres away HR had risen by 48%. This is to be expected, as is the finding that HR response to this new, more fearsome predator was greater than that to sheathbills.

Wilson et. al (1991) similarly removed two incubating Adelies from their nest, operated on them, and returned them to their protected eggs within one hour with a telemetric device implanted in their chest cavities. The birds subsequently were not handled and continued to breed apparently normally (N.B. Culik et. al, 1990, report "very low" breeding success in experimental birds although they seemed to be breeding normally (p. 181)). However, the researchers did other work in the area for the next month. Presumably, they waited for this month to maximise time between initial manipulation and trial, and they used a bird which was nesting five metres from the hut and which, they argue, should therefore have been habituated. A single person slowly but directly approached the bird from 50 to four metres, by which time its HR had increased by 78% from a resting rate of 76bpm. Subsequent (re)capture of the bird by the predator caused its HR to increase to a staggering 287bpm, a rise of 278%. In discussing the results, they argue that the radical HR changes obtained are unlikely to be specific to implanted birds, as subjects behaved apparently normally. This is surprising given that Wilson et. al (1990b) and Wilson et. al (1989) found that Adelies which had been manipulated and fitted with devices were strongly affected by the devices, but did not emit aberrant behaviour in the presence of researchers.

In both studies, the human made a direct approach to birds, so a significant HR increase is to be expected anyway. The point is that the magnitude of increase measured is the magnitude relevant to a predator larger and more threatening than the traditional skua or sheathbill. To be fair to Culik, Wilson and colleagues, it is easy to interpret the results in the dramatic way which they and those who quote them do (e.g. Manheim, 1990; Appendix 2). Our system of categorization of the environment readily makes the leap between a gigantic HR increase in response to approach by a person, and the supposition that a tourist or scientist 15 metres away invokes great stress. But animals have a different perspective of their environment. We must recognise that two actions which we see as equivalent may be worlds apart through a penguin's eyes. From the human approach model it should be clear that a predator recapturing a bird and first-time exposure to a scientist or tourist sitting quietly 15 metres away are, indeed, worlds apart.

Ball and Amlaner (1979) and Heise (1989) also provide examples of HR changes during predator response in birds (Appendix 3) when directly approached by a human. As predicted by the model, both studies report no habituation over the limited number of trials. Animals do not habituate to predators, even learned predators if the learning experience was strong enough, or if the objects in question continue to behave like predators. Continued exposure should actually make the response worse. This is what seems to have occurred in Oelke (1975) and Lishman (1985).

One final point is that Wilson et.al 's (1991) implanted birds *did* produce normal chicks. Thus, the stress involved in one or two isolated contacts with the predator, and exposure to it at a distance over the month, were not sufficient to prevent breeding. Penguins regularly manage to breed in the presence of other predators. The important aspect is determining how we affect Antarctic penguins so that this knowledge will enable us to avoid affecting them.

As for the contradiction between Wilson et.al's (1991) report of enormous commuting penguin deviation in response to one person 20 metres away, and that of others who describe penguins approaching them: a single penguin running up to a person is a single penguin running up to a person, but a deviating penguin is one in a group following other penguins. To induce all commuting penguins to deviate, it is only necessary that some birds start the trend. Birds, for example, that have reason to fear the person. Wilson and colleagues were at Esperanza to carry out "physiological and ecological" work (p.363) and may have created a number of such penguins. This explanation that birds were reacting to each other and not the human is supported by the fact that detouring continued for at least four hours after the person left.

**4.5: Other variables which affect the interaction**

The human approach model describes interaction between one person and one penguin. Yet, as illustrated many times here, penguins affect each other's behaviour. According to van Heezik and Seddon (1990), the smaller the size of previously undisturbed penguin groups, the more tolerant they were of human approach. This result is in the direction suggested earlier (3.4) but the response-modifying effects of penguin group size require further investigation. Similarly, there may be several predators or 100 unknown objects wandering around a rookery. More than one person present will probably represent a new kind of stimulus, producing a unique reaction and not merely an intensified version of the response to one. Ollason and

Dunnet (1980) found that breeding success in the fulmar *Fulmarus glacialis* was significantly lowered when 12 observers were present for three to four days during hatching, but not when two to six observers were present for two to three weeks during laying. Several variables are confounded here, and the response to this stimulus configuration is likely to be different from a summation of the responses to each individually.

### 4.6: Summary and implications

An Antarctic penguin has no natural stimulus template with which to interpret the approach or behaviour of a person. Contrary to intuitive expectations, penguin reaction to humans is not determined by a few factors which are inherently present in any human-penguin contact. As suggested by the work of Nimon and Dalziel (1992; **1.5**), it appears that penguins respond differently to the different stimulus aspects embodied in the range of human behaviours emitted near them. One such stimulus aspect is the speed at which a human may approach. Other stimulus aspects emerge during approach and handling.

A person some distance away is a new, mildly disturbing addition to the environment. At some stage during a gradual approach, it crosses the danger threshold distance (DTD; identified by a change in penguin response), at which point it is large enough and close enough to be threatening. Wilson et.al (1991, p.368) argue that the physiological stress induced by approach is the same for all nesting birds, and only the subsequent emission of fleeing behaviour varies according to current breeding investment. Thus, it might be possible to measure a threshold of physiological stress response, indicating the DTD, at a reasonably consistent person-nesting penguin distance. Alternatively, the actual distance at which a person becomes threatening may vary with breeding stage, for example, a bird with eggs might show signs of alertness, cessation of activity, HR increase, or other responses, at a greater person-penguin distance than a bird brooding large chicks, as well as differences in subsequent overt reaction. A bird with no offspring will probably retreat as soon as an approaching person becomes threatening, but with less impetus to be wary, will probably tolerate approach to a closer distance before the DTD is reached. The DTD probably varies with species and individual also.

Repeated exposure to harmless persons beyond the DTD, particularly if aided by the constancy of other factors - such as clothing colour, behaviour, sounds - should lead to habituation in which the DTD should decrease, probably to a certain minimum limit. However, the practical ramifications of habituating birds are difficult.

To habituate to a stimulus an animal must be regularly and reliably exposed to that stimulus in the absence of any adverse consequence. A small group of people in the same place at consistently spaced intervals might achieve this, but tourist visits would have to be properly coordinated, and tourists would have to be very well schooled to ensure that their behaviour maintained the appropriate stimulus aspects. Habituation would not occur if people were acting according to their own varying interpretations of harmful behaviour towards a penguin.

If a person catches or handles a bird, or eggs or chick, the penguin involved learns that people are predators. This learning experience will modify subsequent response to humans. There may be a series of new thresholds: with regular exposure to people behaving as predators, penguins will become more adept at identifying them, thus responding (at least with alertness) earlier. A penguin which sees a predator will also respond more intensely than a naive bird to a person at the same distance. Predator learning is likely to endure.

Wilson, Culik and colleagues have attempted to control as many variables as possible, and their work is careful and well-informed. Many of the problems in their interpretation suggested here are caused by the use of a technology which has been hailed by many as a brilliant way of avoiding interference with animals (see Amlaner and Macdonald, 1979). But their two single season studies, one of which was merely opportunistic, do not comprehensively and conclusively represent interactions between Antarctic penguins and nearby people, and do not justify attacks on the apparently unscrupulous methodology of Trivelpiece (Appendix 2), and Oelke (Wilson et.al, 1991, p.368). Their recommendations - that people remain at least 30 metres from nesting penguins, and 100 metres from commuting penguins "unless absolutely necessary" (p.369, Appendix 7) - are prematurely formulated. A penguin may not even be able to see a person until it is much closer. Only further research can determine what the distance value of the DTD and other thresholds may be.

# CHAPTER FIVE: THE EFFECTS OF SCIENTIFIC METHODS ON PENGUIN BEHAVIOUR

The arguments of the last chapter suggest that close approach, handling and manipulation of penguins have the potential to affect the birds' welfare and subsequent behaviour in the presence of humans. This chapter develops these ideas in relation to the unique problems posed by scientific study. It examines the relative disturbance induced by various methods, seeks alternative procedures which may have less effect, and discusses the implications of the evidence presented for our knowledge of the natural behaviour of Antarctic penguins.

Antarctic penguins are studied not only for their intrinsic interest but also because their adaptations to extreme conditions inform our general understanding of life. Penguins are crucial components of the Southern Ocean marine ecosystem, and the Scientific Committee of CCAMLR uses information on their populations as a basis for conservation (CCAMLR, 1985). CCAMLR (1988) recommends standard methods for monitoring populations which attempt to ensure that "...the monitoring activities themselves will not induce any excessive disturbance of the animals or give rise to biased results" (p. 1).

Yet, as demonstrated, even seemingly harmless human activities may subtly affect Antarctic penguins, and techniques for the capture, weighing, sexing, diet analysis, marking and biotelemetric measurement of penguins are often inherently invasive. Widely used procedures, including those selected by CCAMLR (1988), can lead to results which are scientifically questionable and ethically unacceptable.

**5.1: Invasive techniques involving handling - capture, sexing, weighing and diet analysis**

Scientists conducting physiological experiments on penguins may neglect to mention the capture and confinement of birds amongst their procedures, even when subsequent operations are scrutinized for reliability (e.g. Boyd and Sladen, 1971). Yet, both penguin welfare and research results can be significantly affected. Noting recent interest in the effects of fasting on metabolism and hormone levels in emperor penguins, Groscolas and Leloup (1989) determined that the captivity imposed on experimental birds could severely affect these parameters. They captured, transported and penned 16 emperors. Taking single samples from each bird, they found that captivity-induced stress had an inhibitory effect on thyroid function. They also found an increase in plasma triiodothyronine levels the day after confinement "in parallel with a rise in daily body mass loss" (p.108), which was attributed to an increase in restlessness.

The problem with this explanation is that measurement of weight change had to come from birds which were handled regularly for weighing. Recalling Boyd and Sladen's (1971) finding of an increase in internal temperature following weighing, restlessness alone may not account for weight loss in these birds. Furthermore, predator learning was regularly reinforced through handling, thus the mere proximity of humans was probably more anxiety-inducing for these birds than for those subjected to only initial capture and a single blood sample. It is likely that these experimental birds lost weight at a greater rate than the others. This is a seemingly inescapable paradox: even attempts to measure the effects of scientific methods will be biased by measurement.

Evidence from several bird studies suggests that it is possible to eliminate the predator response in chicks if they are removed from parents at an early age and handled regularly (Hughes and Black, 1976; Jones and Faure, 1981; Heise, 1989; Culik et.al, 1991). The behaviour of such chicks, hand-reared by humans, would not represent that of wild penguins. However, this might be a way of conducting less biased physiological experiments, provided that the parameters in question were not very strongly associated with environmental or social cues. It is not clear whether or not this habituation would remain as the chick matured (it does not in dometic hens; Hughes and Black, 1976), and researchers should reconsider the necessity of experiments which would inflict this disturbance on Antarctic penguins.

There are several ways in which it might be possible to avoid or limit the effects of invasive procedures for determining sex, weight or dietary intake of Antarctic penguins.

Observational techniques sometimes offer an alternative. One unequivocal method of sexing these monomorphic birds is cloacal examination (CCAMLR, 1988; Trivelpiece et.al, 1990). However, Ainley et.al (1983, p.20) list several behaviours which they consider equally reliable indications of gender, such as copulation position, and clearly discernible treadmarks on the back of the smaller member of the pair, in conjunction with a normal incubation routine. Certainly, observational techniques take more time, and it is possible that these behaviours might not be witnessed by observers. However, in certain circumstances, researchers may be able to avoid sexing altogether. In describing procedure A1.1 for obtaining weight and sex as penguins arrive at breeding sites, CCAMLR (1988, p.15) recommends increasing sample size as an alternative to sexing birds. This augments the chances of measurements falling neatly into a clear division. A brief report in *Nature* (*350*, 305: 1991) describes a plan by Knowles Kerry to build a concealed weighbridge on a path which penguins must cross to reach their colony. With such an instrument, researchers might be able to measure parameter A1.1 without any physical interference at all (although it is unclear how one bird would be measured at a time, and the accompanying figure depicts a human "custodian" of the weighbridge).

Technological innovations might also allow unobtrusive weighing of nesting birds. Sibly and McCleery (1980) designed a balance from which remote readings can be made, and advise arranging it beneath the bird's nest. Prince and Walton (1984) designed such a system for weighing albatrosses which they attach to artificial nests. Many species of birds will shift to artificial nests if they are placed at their habitual sites (Poole and Shoukimas, 1982), and it might be possible to provide such nests for penguins prior to their arrival, thus allowing automatic weighing whilst avoiding any interaction. Whether penguins would adopt nests which they have not made themselves is a matter for further research.

It is difficult to imagine how diet analysis might be made via non-invasive procedures. While the traditional method of obtaining samples was to kill the birds, now non-lethal techniques, such as emetics and stomach pumping, are considered (Montague and Cullen, 1985). They are still strongly invasive, involving catching, holding and manipulating birds in ways that cannot fail to induce trauma. Emison's (1968) original stomach pump easily becomes blocked, and emetics may have no result, or may even cause death (Croxall and Prince, 1980; Montague and Cullen, 1985). The method recommended by CCAMLR (1988), Wilson's (1984) stomach flushing technique, obtains samples by pumping water into the base of the stomach and up-ending the bird. This is undoubtedly distressing, but the method can be used by just one person, an improvement on techniques requiring at least two to restrain the penguin (e.g. Randall and Davidson, 1981), and it is efficient, so that repeated interference is not necessary (although not all have found it practical; Montague and Cullen, 1985).

When procedures are necessarily invasive, one can at least reduce harmful effects by choosing the most appropriate phase of breeding. Although chicks are deprived of food when their parents are stomach pumped, large chicks are probably better able to cope with the loss than brooded chicks (presumably for this reason, CCAMLR (1988) recommends that food samples are taken from adults during the creching phase). One should also question whether the utility of results justifies disturbance, although diet analysis is a high priority component of CCAMLR's Ecosystem Monitoring Program. Subsequent behaviour in the presence of humans is likely to be affected, and these birds may be spoiled for studies of natural behaviour which require that researchers sit within a distance at which they are identifiable.

### 5.2: Marking for recognition

Recognising individuals is generally an essential component of any systematic field study of animals (Delany, 1978). Although this can sometimes be accomplished by recording individual variation in morphology (e.g. differences in bill pattern; Scott, 1978), there do not appear to be any records of such methods used in relation to Antarctic penguins, and their monomorphism, combined with the dense groupings in which they breed, renders artificial marking necessary.

Short term marking of birds is often achieved through the use of brightly coloured dyes (Tickell, 1968; Ainley et.al, 1983; Robertson, 1990). However, colour is a complex stimulus important in many aspects of bird behaviour (Patterson, 1978; Cott, 1985), and Antarctic penguins are patterned in very specific ways. It is questionable to assume them to be indifferent to human-induced changes in this patterning (Wilson et.al, 1990b).

Suspecting that colour of attached packages would affect Adelie penguin behaviour, Wilson et. al (1990b) experimented with black, white, blue, red and yellow packages affixed to birds' backs with tape. Having attached peck activity recorders (Wilson and Wilson, 1989) to these packages, they found that significantly more high pressure pecks were given to those which did not match plumage colour. As the white belly and black back of penguins may be camouflage against seals above or below them (Murphy, 1959; Ackerman, 1989), it seems likely that any affront to this pattern would be disturbing. The exception to this finding was that red packages (as well as black) were pecked significantly less than the other colours.

Wilson et. al (1990b) cite Bowmaker and Martin (1985), suggesting that penguins are insensitive to light of longer wavelength. The latter found that red-sensitive receptors were absent in humboldti penguins *Spheniscus humboldti* and concluded that birds should be capable of good wave-length discrimination in the blue-green region of the spectrum, but incapable of any discrimination above 550 nanometres. This seems to be an adaptation to life in oceanic and deep coastal waters, where there is little light in the spectral region beyond 575nm. Given the ocean-bound lifestyle of Adelies there is little reason why they should be able to discern red either. If confirmed, this would be a useful finding as it suggests that researchers may be able to squirt red dyes on Adelies, possibly from some distance, and that neither birds nor leopard seals may be able to see it.

However, this is unlikely to be true of king and emperor penguins which have golden/orange colouration on their necks and purple/red bill plates. There is some evidence that their colouring is an aid to interspecific recognition (Murphy, 1959), and birds on which the orange patch is overpainted appear to have difficulty in forming pairs (Stonehouse, 1960, p. 28; Jouventin, 1982, pp. 98-99). Birds which use colour markings in pair formation will be differently affected by colour alteration from those, such as green-dyed Adelies, whose underwater camouflage may be ruined. Burley et.al (1982) found that zebra finches *Poephila guttata* preferred partners with leg bands the same colour as the other sex's plumage above unbanded birds, and showed avoidance of those whose band colours differed greatly from plumage colour. This suggests that band colours accentuated or attenuated naturally occurring colour signals. Thus, marking king or emperor penguins with red or orange dye may significantly affect the penguins' social interactions (Figure 13).

Another implication of these suggestions is that they compliment the hypothesis (4.3) that a person in a red jacket (of the kind generally distributed by Antarctic tour companies) 15 metres away may appear small; he or she may also be the same colour as the back of another penguin to an Adelie. On the other hand, tourists to king penguin colonies may unwittingly be having other effects (see Figure 14).

Numbered bands of metal or plastic are used for more durable marking (e.g. Sladen and Penney, 1960; Figure 15), and would seem to be irreplacable in providing long term demographic and individual information. Bands around the base of the flipper can be seen at a distance, much to the delight of ornithologists seeking humane methods of recognition marking (e.g. Spencer, 1978).

Yet, evidence from Cape Hallett, where humans disturbed penguins over the 16 years for which the station was occupied (Wilson et.al, 1990a), suggests that banding may have severely deleterious effects on Antarctic penguins when combined with other forms of intensive scientific study and, perhaps, station activity.

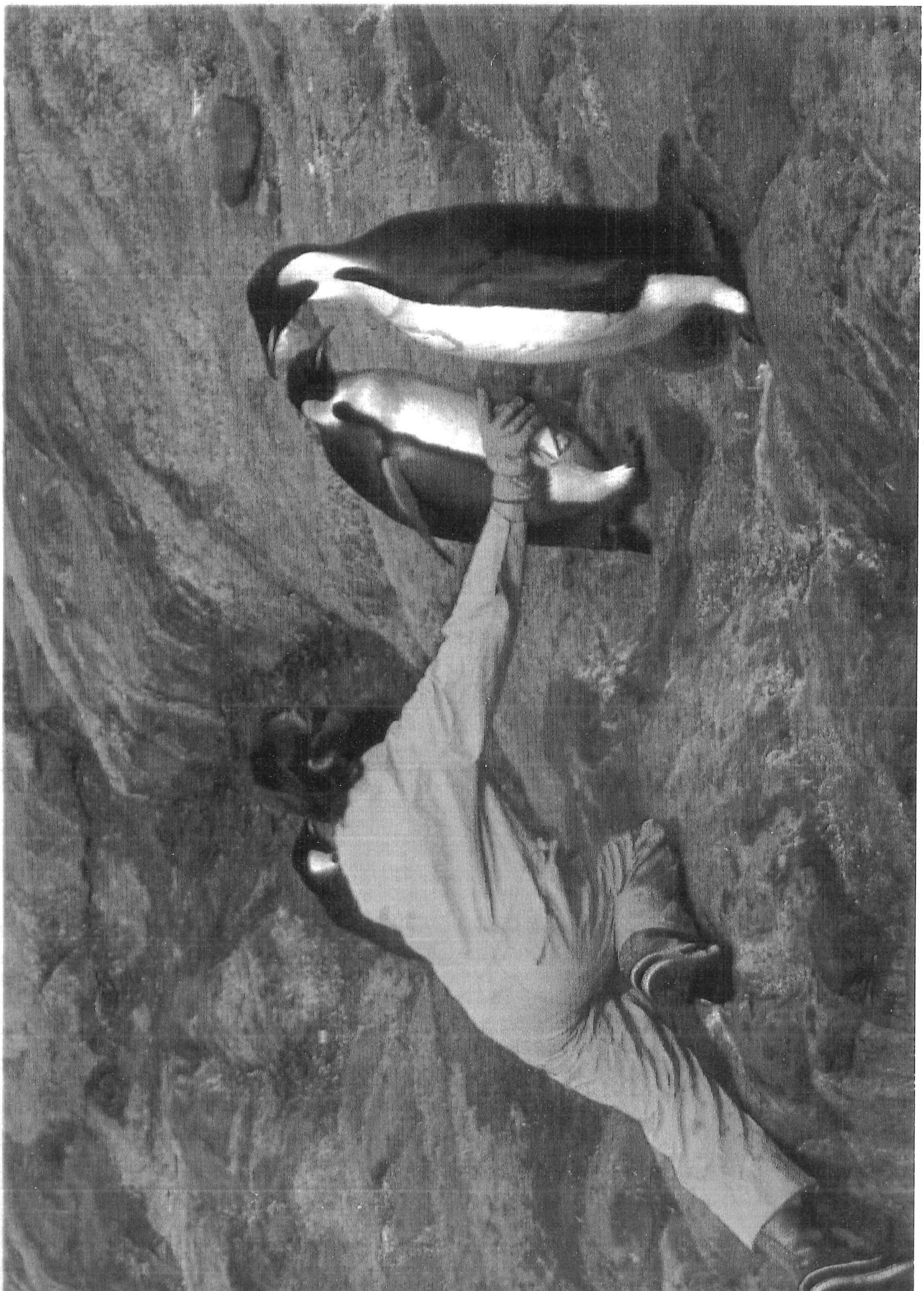

Figure 13. Painting penguins. Dye is used as a temporary method of marking penguins for recognition, but the changed appearance may affect birds' social interactions (Robertson (1990), p. 91).

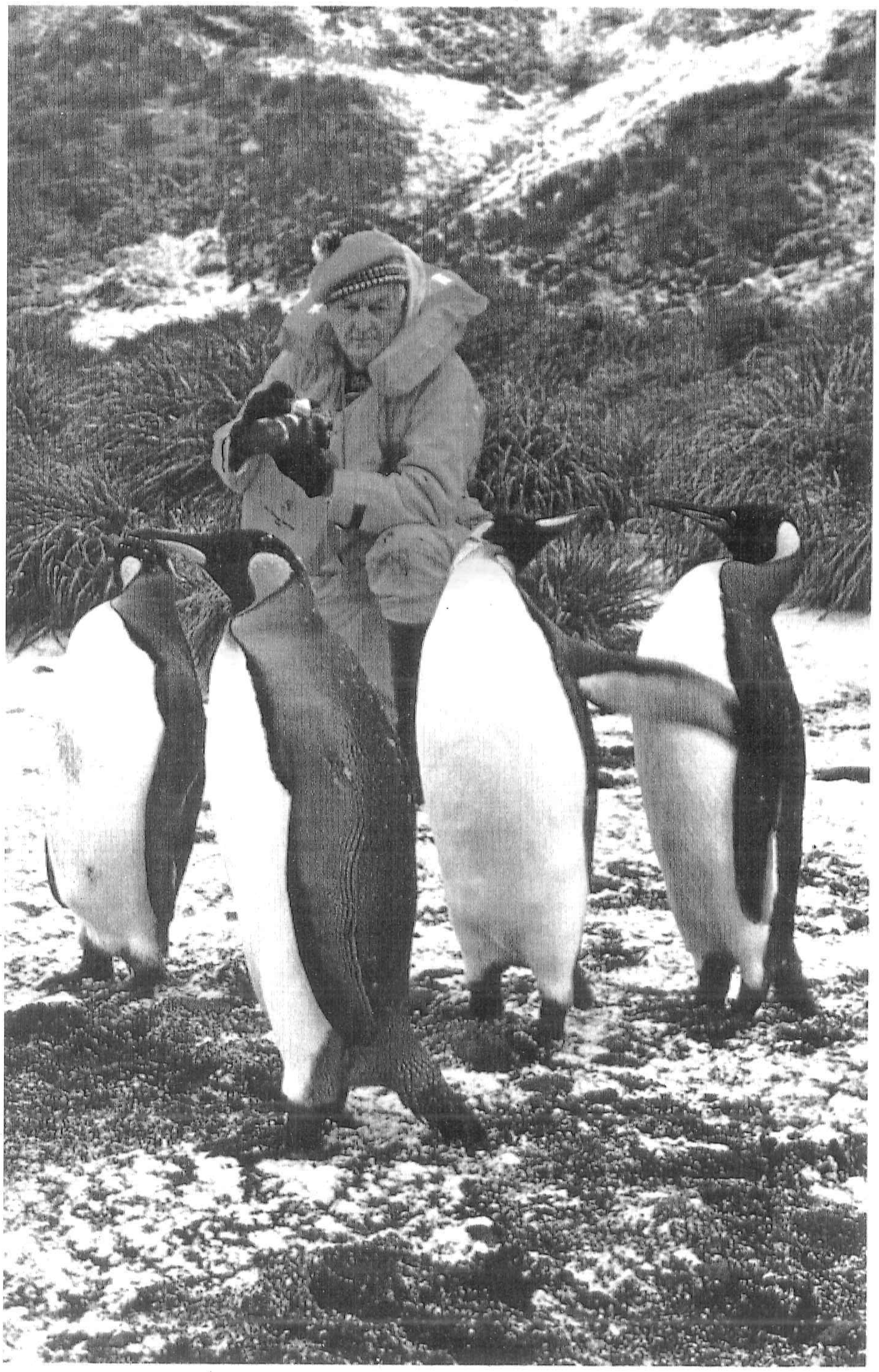

Figure 14. Possible effects of colour. Tinbergen (1953) describes a male stickleback behaving as if trying to attack a red post office van, for red is a sign stimulus for aggression in these fish. Bright orange is an important signal in king penguin pair formation (Stonehouse, 1960; Jouventin, 1982). Whichever approached the other first, this man may be evoking stimuli of which he is unaware.

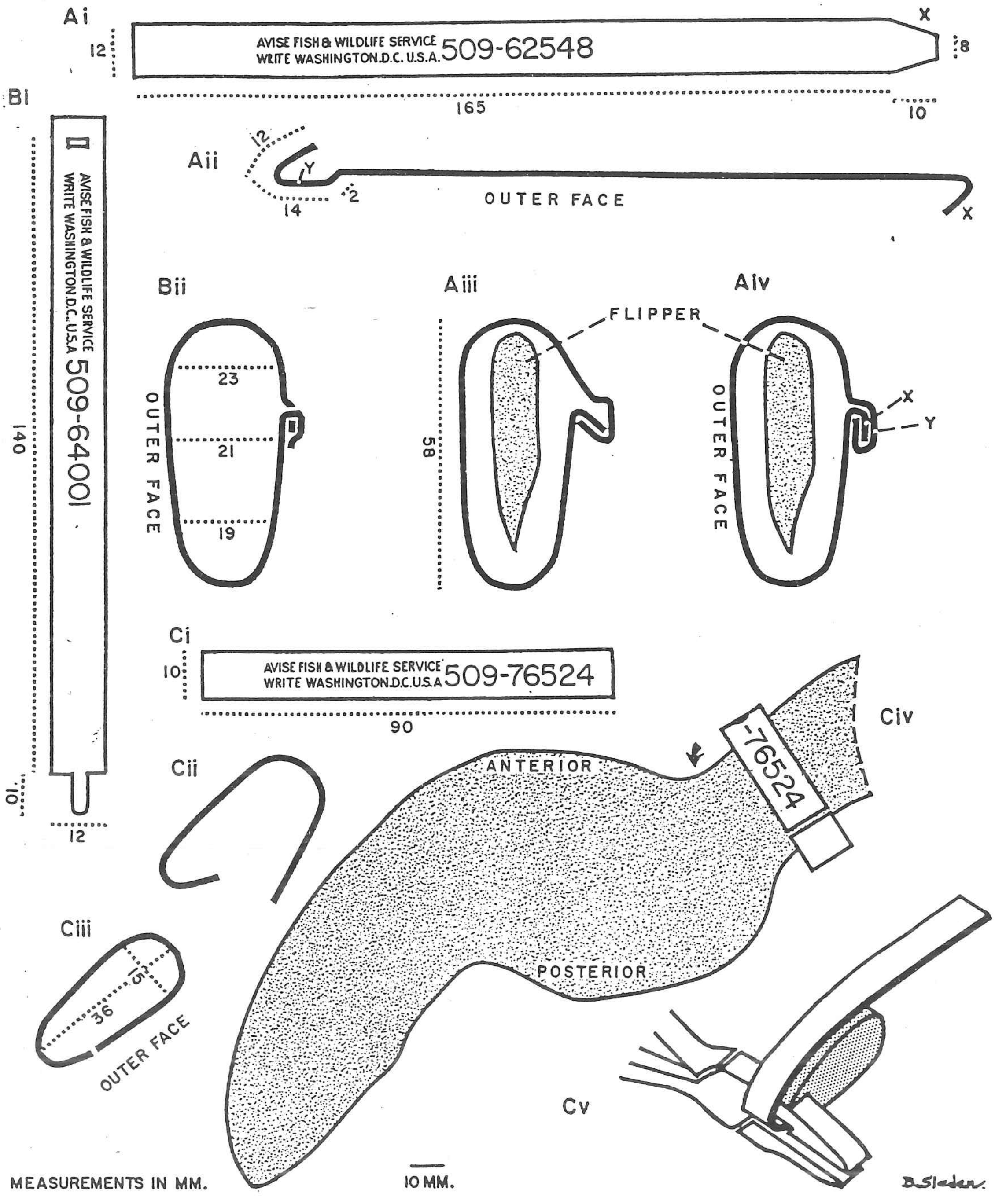


Figure 15. Penguin flipper bands.
A. 1958 design for emperor penguin, i) first shaping, ii) second shaping, iii) shaped around flipper, iv) final position.
B. 1959 design for emperor penguin, i) strip as supplied, ii) final position around flipper.
C. 1958 and 1959 design for Adelie and chinstrap penguins, i) the strip supplied in 1958, cut to correct length, ii) the pre-shaped band supplied in 1959, iii)-iv) final position around flipper, v) pliers for shaping (Sladen and Penney (1960), p.80).

Reid (1968) reports that of nine Adelie penguin subcolonies banded and fervently studied from 1958/59 still undisturbed by station activities in 1962/63, six had declined by more than 90% in 1964/65. The sites of 15 other subcolonies remote from the station but also banded in 1961/1962 were identified by Wilson et.al (1990a) in aerial photographs taken from 1981 to 1987. One subcolony was abandoned, one supported a single nest, four had declined by 70% by 1981, and the total population of the other nine was less than 10% of that in 1962. There were substantial declines in many Ross Sea Adelie populations over the mid-to-late sixties (Taylor et.al, 1990), but it appears that banding at least contributed to the demise of these groups, as 15 control subcolonies close to them had decreased by only 40% between 1962 and 1981 (Wilson et.al, 1990a).

Cranfield et.al (undated, cited in Wilson et.al, 1990a) shed further light on the effects of disturbance at Cape Hallett. They divided the colony into nine zones and followed population changes from 1960/61 to 1964/65. The colony as a whole declined by 13.5% over this period, but the changes per subcolony varied greatly. Increases of between 11.9% and 57% occurred in zones that were least disturbed, decreases were found in those colonies identified by Reid (1968), and those closest to the station or roads, which declined by up to 40%. They also found a 33% decline in adults banded but not subjected to further study. This is approximately the proportion (26%) of banded breeding Adelies which Sladen and Penney (1960) lost between seasons. Similarly, Ainley et.al (1983, pp.191-192) found mortality was 28% higher in Adelies during their first year after banding than that of birds with older bands. They suggest this results from complications in blood flow when the wing swells during moulting, and that induced mortality would occur only once, during the young Adelie's first moult. However, the mortality which they report occurred in birds four to seven years old which had been rebanded.

What processes might explain these findings? Banding can induce mortality in some birds, as found by Ainley et.al (1983), but this is unlikely to be the sole cause of declines. From the arguments developed here, we would expect that close study of breeding penguins which had previously been handled would be traumatic for birds, but this explains neither the magnitude of declines, nor apparent decreases in those not subsequently studied. Perhaps there is something particularly distressing for a penguin in having a person change its morphology during handling, leaving a long lasting consequence of the threat which such a predator embodies, and altering a form which is ideally adapted to underwater manoeuvrability and camouflage (whether or not the alteration affects these things). Wilson et.al (1989) cite psychological distress to explain why brooding Adelies which had one centimetre clipped from their tail feathers took 50% longer than unmarked birds on their next foraging trip (the only one measured).

Some breeding adults may be induced by banding to desert established grounds and breed elsewhere, this impetus being even stronger in those subjected to further intensive studying. Members of the United States Bird Banding Program found banded birds exchanged between neighboring rookeries, and although they recovered few bands from penguins in different areas, Sladen et.al (1968b) suspected that many more exchanges were occurring than those detected: "every team member searching diligently for banded penguins in a new part of the Ross Sea area has found some" (p.226). Furthermore, migrations may remain undetected if destination rookeries are not visited or are unknown (Taylor et.al (1990) recently discovered 11 previously unreported rookeries in the Ross Sea region). Wilson et.al's (1990a) evidence that the population of banded Cape Hallett colonies remained low suggests that established breeders may have set themselves up elsewhere permanently.

These results relate to adults breeding in an established territory. Banding chicks may produce different results, as their learning about their environment is less firmly established, and they may get used to a tag or band. Ainley et.al's (1983) suggestion that physical aspects of the band may cause mortality amongst a proportion of birds in their first 18 months, and may not subsequently greatly affect survivors is plausible. Perhaps Richdale's (1957) finding that about 85% of yellow-eyed penguin *Megadyptes antipodes* (banded) chicks die in their first year or two is affected by such a process.

Hill and Talent's (1990) methods may help those who must band Antarctic penguins to at least reduce disturbance to some extent. Their capture, banding and radio-marking of least terns *Sterna antillarum athalassos* and snowy plovers *Charadrius alexandrinus nivosus* was accomplished by setting traps for birds and placing a bag over their heads to reduce visual cues prior to handling. These processes reduce human contact with the bird and might result in an effect comparable to natural interferences, such as change in morphology from wounds incurred during congener attack. Also taking the trouble to paint radio tracking devices to blend with plumage colour, they found no adverse effects of these processes on breeding success. It must be remembered, however, that Ainley et.al (1983, p.188) also found that productivity between banded and unbanded birds closely agreed. They fail to mention the 28% mortality in banded birds at this point.

### 5.3: Packages attached to penguins

Penguins spend most of their time in the ocean where it is difficult to measure their behaviour. However, remote monitoring packages, for example depth and speed gauges (Wilson and Bain, 1984a, 1984b) and biotelemetric devices, provide data about feeding areas and foraging movements at sea (Trivelpiece et.al, 1986; Croxall and Davis, 1990; Sadleir and Lay, 1990). Biotelemetric interventions have been welcomed with enthusiasm throughout the ethological and ecological world in general (see Amlaner and MacDonald, 1979), hailed as a method for the "disturbance free measurement" of biological parameters (Kimmich, 1979, p.3).

Amlaner (1978) recognised that the revolutionary methods of biotelemetry might have some effect on the subjects, but he believed this to be a function of the size and weight of the attachment in relation to that of the animal. Fitting Adelies with packages ranging from three to 48 grams, Wilson et.al (1989) found a significant positive correlation between package size and the percentage of birds not returning from their next foraging trip, with a maximum proportion of four out of seven birds missing after being fitted with a 48g device. However, others have failed to find such a simple relationship between device size and effect (e.g. Greenwood and Sargeant, 1973), and Gales et.al (1990) report only one of 13 fairy penguins *Eudyptula minor* failing to return once fitted with a 60g device.

Those of Wilson et.al's (1989) penguins carrying the larger devices which still returned took much longer than unmarked birds. They may have swum up to 5% slower due to hydrodynamic drag of instruments, but this alone cannot account for longer absences (p.79). Croll et.al (1991) also found that the average foraging trip duration of instrumented chinstraps was longer than controls, but did not significantly protract with increases in device frontal area (hence, hydrodynamic drag). Gales et.al's (1990) finding that instrumented fairy penguins ate as little as half the food of controls, while expending up to 80% of the energy (again, not consistently related to device size) suggests that manoeuvrability and, thus foraging efficiency, may have been affected by attachment of any device. However, trip duration was not affected, so neither reduced speed nor manoeuvrability seem to fully explain the extra time spent at sea by Wilson et.al's (1989) Adelies and Croll et.al's (1991) chinstraps.

Wilson et.al's (1990b) Adelies pecked hard at attached packages while at sea, but this aberrant behaviour was never observed on land by attentive researchers. Animal preoccupation with packages after attachment is very common (Amlaner, 1978), thus, the authors' supposition that (instrumented) birds were too preoccupied with the presence of observers to peck is probably correct. Penguins would be traumatised by capture and attachment of a device, possibly even more so than birds subjected to sexing and weighing whose morphology remains unaltered. Despite finding that average duration of a single foraging trip was only protracted in Adelies wearing 35g and 48g devices, there is evidence that Wilson et.al 's (1989) other experimental birds also behaved abnormally. *Average* duration may not have been affected, but five of the 20 birds fitted with 6g devices were away for as long as any, excepting those which did not return. Also, birds fitted with 3g devices spent significantly less time than their partners at the nest after the third changeover during brooding[1].

1. It is unclear if this is the first point at which such an effect would have become apparent, or whether no such effect occurred until this stage. That a) there was a period around this time (1400 hours, 21 December to 0000 hours, 26 December) during which nests were checked every four hours instead of daily, and b) the period after the third changeover is identified by authors as a time at which chick feeding required frequent changeovers (p.78), suggests the former, but then the difference between experimental and control groups is given in bird days rather than hours.

One possibility is that the predator response is involved. The distress of fitted birds is unapparent on shore, expressed as an acute awareness of the predators and a lack of other behaviour in their presence. However, once at sea, penguins behave strangely. It is likely that they engage in aberrant pecking, although this is not the only reason for long trips, given extended foraging in penguins following tail clipping (Wilson et.al, 1989). They are also probably affected by the physical properties of the package, as described above. But most importantly, like penguins discouraged from returning to shore by helicopter activity (3.3): the birds are scared by their predator experience. They may even be able to see the predators near their partners, as Wilson et.al (1989) checked their nests every hour or so. As would be expected, some take a long time to return, others desert the nest and do not return. Sadleir and Lay (1990) report the outcome of abnormally long foraging trips in nine Adelies wearing devices: two failed to return, the others either deserted or returned too late to save their offspring. Wilson et.al (1989) may have witnessed the same intermediate stages which resulted in breeding site desertion by banded birds.

### 5.4: Implications for studies of the natural behaviour of Antarctic penguins

It is important to recognise that the conclusions drawn here may not apply to all studies in which such methodology is used. The effects of banding, for example, may seem quite drastic, but Jouventin engages in mass banding of penguins and petrels and he has been working in the field for 20 years (Jouventin and Bretagnolle, 1990). Furthermore, it seems that various suggested syndromes, such as strong predator response to package attachment, affect only a proportion of birds. One clear example is found in Sadleir and Lay (1990, pp.160, 168): Although nine of 17 instrumented Adelies took abnormally long foraging trips and were unsuccessful breeders, the other eight appear to have been totally unaffected. It is not at all clear what variables may determine or prevent susceptibility to various disturbances.

What is likely, however, is that measurement and observation have affected conclusions about the 'natural' behaviour of Antarctic penguins to an unrecognised and unquantifiable extent.

Anthropocentric bias means that observer effects are not necessarily considered by researchers. Richdale (1957) saw it as essential that all colonies in the main study area were "worked thoroughly" (p. 1). Burley et. al (1982) report that when they found band colour dependent differences in zebra finches their immediate suspicion was that birds had been banded non-randomly. When observer effects are considered, this anthropocentric bias may influence judgements about them. Ainley et. al (1983) went to the trouble of conducting an experiment to see if their measurements affected Adelie breeding. One group was visited daily, another, weekly. At least the latter group (and possibly both groups) were not handled, and no birds in these groups were banded. Their statement that productivity of banded and unbanded birds closely agreed appears to have been based on a comparison of these groups (p. 188, 174), which may indicate that they considered daily visits to be basically equivalent to banding.

Perhaps most disappointing of all is that seemingly very reasonable precautions may mean little, if the interpretations presented here are correct. For example, Wilson et. al (1989) stayed five metres away from nests when checking for the return of birds with packages, but the suggestion here is that the significant effect occurring involved the bird at sea, not its nest-bound partner. Oelke (1975) took great pains to sit in the same spot wearing the same clothes on each visit, but his attempts at habituation may have been thwarted by the past actions of other people, rendering him a distressing stimulus with a negative influence on breeding success (4.2).

Banding, combined with an assortment of other invasive techniques, has been used as a basis for many of the major sources of information about penguins (e.g. Richdale, 1957; Sladen et.al, 1968b; Ainley et.al, 1983). Similarly, a variety of human-induced effects could have biased any number of Antarctic penguins studies. One can scrutinize the methodology used in research articles for possible observer effects, but often the necessary information is not reported. So much more information about the effects of scientific activity could have been derived from the extreme events at Cape Hallett, but the reports of the time are typically very brief (e.g. Reid, 1968), or unpublished (Cranfield et.al, undated, cited in Wilson et.al, 1990a).

Decisions about methodology and intervention in studies of Antarctic penguins are, therefore, decisions involving largely unpredictable and immeasurable risks to the health and natural behaviour of subjects. These decisions may even influence the outcomes of other studies taking place in subsequent seasons. The only way to tackle measurement effects is through general awareness, and a concerted and consistent research effort to clarify understanding. The best way to maximise the relevant information included in such research, and to provide a consistent framework for knowledge, is to adopt the animal behaviour approach based on penguin-relevant variables.

# CHAPTER SIX: CONCLUSIONS, IMPLICATIONS, FUTURE RESEARCH

We can no longer afford to speak of human disturbance as if it were a single, self-explanatory variable, only evident in salient adverse impacts on penguin colonies. It is, instead, a broad spectrum of human-induced behavioural change involving many factors and requiring much investigation.

Antarctic animals have evolved in the absence not only of humans, but of any natural phenomenon which might provide a stimulus template for interpreting them. The appearance of a human before a naive Antarctic penguin has less preliminary meaning than the appearance of Cook before the Hawaiians. This is a major distinction between Antarctic penguins and animals in almost any other terrestrial environment. Whereas many wild animals smaller than ourselves might simply flee from a creature as large as a person, according to the arguments presented here, Antarctic penguins will react to a multitude of stimulus factors in human behaviour, in a manner complicated by the fact that they are predominantly involved in breeding at the time of such encounters. It is possible for people to have benign interactions with penguins, and it is possible for apparently benign and excusable interventions to detrimentally affect Antarctic penguins. Whatever is learned by the penguin during interactions will affect subsequent behaviour upon contact with humans, and predator learning will have particularly strong and long lasting effects.

Even penguin reaction to aircraft, which might intuitively seem a simple matter of scared birds fleeing from an enormous, noisy stimulus, appears to be quite complicated. Again, different stimulus aspects of penguin-aircraft interactions affect birds differently, and responses will be modified by situational variables, experience and learning.

People in the Antarctic often act as if what they do to penguins does not affect them. Those penguins which are affected have little overt behaviour in which these effects are clearly indicated[1]. Apart from retreating or fleeing, which occurs under only certain circumstances, behavioural change is expressed in cessation of other activity, alertness, physiological change, erratic behaviour at sea, nest or colony desertion, and other unidentified subtle or quantitative change which, for example, gives rise to breeding failure. Understandably, these unobtrusive effects are rarely directly referred to in the literature.

The hypothetical nature of explanations presented is due to the lack of detailed relevant information, and the inconsistency in approach of some who provide pertinent findings. So much more could be known about human disturbance had researchers had a better understanding of what to look for and what to report. A thorough and reliable knowledge base can now be developed through research which adopts the framework described and illustrated here. Even those not attempting to directly measure disturbance may be able to contribute useful information if their comments are made on the basis of a concordant approach. The greater potential of observations made according to an understanding of the stimulus-response basis of human-animal interaction is illustrated in evaluations of the work of Wilson, Culik and their team: it is only because they have been so diligent in identifying and recording relevant variables that it was possible to scrutinize their results to the extent done so here. Using the animal

1. This opinion is also expressed in Wilson et.al (1991).

behaviour approach to maximise the utility of future research not only promotes the progress of scientific inquiry, but is consistent with a philosophy of minimising disturbance to Antarctic animals.

For the same reasons, it is immediately clear that future penguin research of all kinds must be conducted on the basis of the least interactive and invasive methods possible. To achieve this, researchers will have to consider what the stimulus aspects of procedures may be, and how they may interact with situational variables and stage of the breeding cycle to influence response. If the reasons for particular choices are documented, then even if they are later rejected, sufficient information should be available to render results useful. Penguin researchers might consider some of the alternative methods suggested here, or may be better able to devise their own.

The use of noninteractive methodology is even more important for those hoping to study the effects of human behaviour on penguins, as illustrated in the alternative interpretations offered of Culik et.al (1990) and Wilson et.al (1991) (**4.4**). Thorough analysis of behaviour patterns of penguins on shore offers one avenue for measuring affects of nearby humans. Penguins exposed to people may exhibit subtle changes in frequency or time spent in particular activities. Wilson et.al (1989) found differences in nest attendance between instrumented and control birds, for example (**5.3**). Other changes suggested from the review include increased time spent in posture or movements indicating alertness or decreased time spent asleep (which, in themselves, may be harmful to an incubating penguin, 3.4). If researchers need to measure other responses, such as physiological change, then they should develop techniques for doing so with minimal disturbance. For example, a penguin could be put to sleep prior to handling with a dart fired from afar. Like Hill and Talent's methods (1990, 5.2), this would prevent association between people and stressful experiences.

Given these considerations, future inquiry into human disturbance of Antarctic penguins could attempt to test or measure the processes discussed here. These arguments should suggest many avenues for exploration, and some specific suggestions are made in the chapter summaries. Issues of immediate importance include elaboration of the human approach model. Using noninteractive measures of stress, researchers might be able to identify the danger threshold distance in naive birds, identifying whether or not it varies with stage of the breeding cycle, and to what it extent it may be reduced by habituation to innocuous human presence. Such results would be of prime significance in providing truly well-founded guidelines for visitors and scientists hoping to observe undisturbed behaviour. Future human disturbance research must also seek understanding of species differences and differences in response according to situational or contextual variables such as location, or the occurrence of mixed species colonies. Furthermore, the analyses made here do not even begin to examine penguin response to entire stimulus configurations - such as several people gradually approaching a small colony during brooding.

Some of these questions will be considered by researchers involved in Project Antarctic Conservation. Initiated by the Polar Ecology and Management Group of Scott Polar Research Institute (SPRI), and involving British, Argentinian and Chilean scientists, this long-term venture is designed to examine problems and processes of ecotourism in the Antarctic Peninsula region. Preliminary monitoring studies of tourist visits and their impact on fauna and flora were carried out on Half Moon Island in the 1991/92 season (Stonehouse, 1992). Detailed investigation of visitor-

Antarctic penguin interaction by Stonehouse and Nimon of SPRI is scheduled for the 1992/93 season on Nelson Island, South Shetland Islands.

Once the processes and forms of human-Antarctic penguin encounters are understood, this information can only be used appropriately by putting it back into the context of what people actually do in the Antarctic. It may be desirable to require that all who visit the region respect its intrinsic values and follow sound guidelines to avoid disturbance, but this is of little use if people are unconcerned or perceive themselves as unbound by such restrictions. Manheim (1990, p. 5) mentions sightings of people kicking seals or hugging penguins for photographs, and Halle (1973) describes people waltzing and wrestling with birds which they had apparently classified upon sight as "stage entertainment" (p. 60). The *Agreed Measures* are simple guidelines, available since 1964, yet violations of even these official recommendations may be relatively common (Greenpeace International, 1990). It is to be hoped that recent advances in the cause of Antarctic conservation indicate concern on behalf of the majority of people involved with the Antarctic, and those dragging their ideological feet can be appropriately conditioned by a campaign of awareness and information.

IAATO'S Antarctica Visitor Guidelines should be endorsed, distributed, and exemplified by all Treaty Nations, tour operators and other concerned parties until such time as research provides sufficient information for the creation of a comprehensive, reliable guide to the prevention of disturbance. These are the most specific and supportable of all recent attempts to design guidelines, and they are formulated in such a way as to win people's loyalty - for example, explaining the reasons for particular restrictions, rather than just listing orders. In relation to aircraft activity, the optimal policy is that the further they stay away from penguins the better. On occasions when logistics require approach of a penguin colony to any distance at which craft can be seen or heard by birds, then at least ground-based observers could acquire as much information as possible from unavoidable disturbance.

Understanding human-Antarctic penguin interaction is just one small part of understanding human impact on the Antarctic environment, which is just one small step in the conservation process. The arguments presented represent one perspective of the literature, the endorsement or rejection of which can only be determined by further investigation. What is important is that some of these arguments should inspire further investigation. Perhaps researchers now have a base from which to begin.

# REFERENCES


Ackerman, D. 1989. A reporter at large: Penguins. *New Yorker*, July 10, pp. 38-47, 50, 52-67.

Ainley, DG. 1975. Displays of Adelie penguins: a reinterpretation. *In:* B Stonehouse (ed.), *The Biology of Penguins*. London, Macmillan, pp. 503-534.

Ainley, DG, LeResche, RE, and Sladen, WJL. 1983. *Breeding biology of the Adelie penguin*. Berkley, University of California Press.

Ainley, DG, Morrell, SH, and Wood, RC. 1986. South Polar skua breeding colonies in the Ross Sea region, Antarctica. *Notornis, Vol. 33(3)*: 155-163.

Amlaner, CJ. 1978. Biotelemetry from free-ranging animals. *In:* B Stonehouse (ed.), *Animal marking: recognition marking of animals in research*. London, Macmillan, pp. 205-228.

Amlaner, CJ, Jr, and Macdonald, DW, (eds.). 1979. *A handbook on biotelemetry and radio tracking*. Oxford, Pergamon Press.

Anderson, I. 1990. Mystery of the dead king penguins. *Nature, Vol. 127(1723)*: 35.

Anon. 1991. Tourism: let sleeping dogs lie. *Nature, Vol. 350*: 291.

Antarctic and Southern Ocean Coalition (ASOC). 1991. A critique of the Protocol on Environmental Protection to the Antarctic Treaty. *XVI ATCM/INFO 21, 8 October 1991.*

Antarctic Treaty Consultative Parties (ATCP). 1991a. Antarctic tour operators form association. *XVI ATCM/INFO 20, 8 October, 1991.*

Antarctic Treaty Consultative Parties (ATCP). 1991b. Guidelines for tour operators and tourists. *XVI ATCM/INFO 58, 9 October, 1991.*

Ball, NJ, and Amlaner, CJ, Jr. 1979. Changing heart rates of herring gulls when approached by humans. *In:* CJ Amlaner, Jr, and DW Macdonald, *A handbook on biotelemetry and radio tracking*. Oxford, Pergamon Press, pp. 589-594.

Benninghoff, WS, and Bonner, WN. 1985. *Man's impact on the Antarctic environment*. Cambridge, Scientific Committee on Antarctic Research (SCAR).

Birke, L, and Michael, M. 1992. The researcher's dilemma. *New Scientist, Vol. 134(1815)*: 25-28.

Bolles, RC. 1970. Species-specific defense reactions and avoidance learning. *Psychological Review, Vol. 77*: 32-48.

Bonner, WN. 1978. Man's impact on seals. *Mammal Review, Vol. 8(1,2)*: 3-13.

Bonner, WN. 1984. Conservation and the Antarctic. *In:* RM Laws (ed.), *Antarctic ecology*, Volume 2. London, Academic Press, pp. 821-850.

Bowmaker, JK, and Martin, GR. 1985. Visual pigments and oil droplets in the penguin *Spheniscus humboldti*. *Journal of Comparative Physiology A, Vol. 156*: 71-77.

Boyd, JC, and Sladen, WJL. 1971. Telemetry studies of the internal body temperatures of Adelie and emperor penguins at Cape Crozier, Ross Island, Antarctica. *The Auk, Vol. 88*: 366-380.

Boyd, JC, Sladen, WJL, and Baldwin, HA. 1967. Biotelemetry of penguin body temperatures, 1966-1967. *Antarctic Journal of the United States, Vol. 2(4)*: 97-99.

Brewster, B. 1982. *Antarctica: wilderness at risk*. Melbourne, Sun Books.

Budd, GM. 1962. Population studies in rookeries of the emperor penguin *Aptenodytes forsteri*. *Proceedings of the Zoological Society of London, Vol. 39*: 365-388.

Burley, N, Krantzberg, G, and Radman, P. 1982. Influence of colourbanding on the conspecific preferences of zebra finches. *Animal Behaviour, Vol. 30*: 444-455.

Cahill, T. 1992. Spared. *Travel Holiday, March*: 89-141.

Convention on the Conservation of Antarctic Marine Living Resources (1985). *Report of the fourth meeting of the Scientific Committee (SC-CAMLR-IV): Hobart, Australia, 2-9 September, 1985.*

Convention on the Conservation of Antarctic Marine Living Resources (1988). *Standard methods for monitoring parameters of predatory species*. CCAMLR Ecosystem Monitoring Program, Hobart, Australia.

Cott, HB. 1985. Coloration, adaptive. *In:* B Campbell and E Lack (eds.), *A dictionary of birds*. Vermillion, Buteo Books, pp. 97-100.

Croll, DA, Osmek, SD, and Bengston, JL. 1991. An effect of instrument attachment on foraging trip duration in chinstrap penguins. *The Condor, Vol. 93*: 777-779.

Croxall, JP, and Kirkwood, ED. 1979. *The distribution of penguins on the Antarctic Peninsula and islands of the Scotia Sea*. Cambridge, British Antarctic Survey, Natural Environment Research Council.

Croxall, JP, and Prince, PA. 1980. The food of Gentoo penguins *Pygoscelis papua* and Macaroni penguins *Eudyptes chrysolophus* at South Georgia. *Ibis, Vol. 122*: 245-253.

Croxall, JP, Rootes, DM, and Price, RA. 1981. Increases in penguin populations at Signy Island, South Orkney Islands. *British Antarctic Survey Bulletin, Vol. 54*: 47-56.

Croxall, JP, and Lishman, JS. 1987. The food and feeding ecology of penguins. *In:* JP Croxall (ed.), *Seabirds: feeding ecology and role in marine ecosystems*. Cambridge, Cambridge University Press, pp. 101-131.

Croxall, JP, and Davis, RW. 1990. Metabolic rate and foraging efficiency in *Pygoscelis* and *Eudyptes* penguins at sea. *In:* LS Davis and JT Darby (eds.), *Penguin Biology*. San Diego, Academic Press, pp. 207-228.

Culik, B, Adelung D, and Woakes, AJ. 1990. The effect of disturbance on the heart rate and behaviour of Adelie penguins *Pygoscelis adelaie* during the breeding season. *In:* KR Kerry and G Hempel (eds.), *Antarctic ecosystems: ecological change and conservation.* Heidelberg, Springer-Verlag, pp. 177-182.

Culik, B, and Wilson, R. 1991. Penguins crowded out? *Nature, Vol. 351:* 340.

Culik, BM, Wilson, RP, Danfeld, R, Adelung, D, Spairani, HJ, Coco Coria, NR. 1991. Pygoscelid penguins in a swim canal. *Polar Biology, Vol. 11*: 277-282.

Davey, G. 1989. *Ecological learning theory.* London, Routledge.

Davis, LS. 1991. Penguin weighting game. *Natural History, Vol. 1:* 46-54.

Davis, LS, and McCaffrey, FT. 1986. Survival analysis of eggs and chicks in Adelie penguins (*Pygoscelis adeliae*). *Auk, Vol. 103*: 379-388.

Davis, LS, and Speirs, EAH. 1990. Mate choice in penguins. *In:* LS Davis and JT Darby, *Penguin Biology.* San Diego, Academic Press, pp. 377-397.

Dawkins, R. 1976. *The selfish gene.* Oxford, Oxford University Press.

Delany, MJ. 1978. Introduction: marking animals for research. *In:* B Stonehouse (ed.), *Animal marking: recognition marking of animals in research.* London, Macmillan, pp. 1-10.

Emison WB. 1968. Feeding preferences of the Adelie penguins *Pygoscelis adeliae* at Cape Crozier, Ross Island. *In:* OL Austin, Jr. (ed.), *Antarctic Bird Studies*, Antarctic Research Series, No. 12. Washington DC, American Geophysical Union, pp. 191-212.

Enzenbacher, DJ. 1991. International association of Antarctic tour operators. *Polar Record, Vol. 27(163)*: 372.

Enzenbacher, DJ. 1992. Tourists in Antarctica: numbers and trends. *Polar Record, Vol. 28(164)*: 17-22.

Ferns, PN, Macalpine-Leny, IH, and Goss-Custard, JD. 1979. Telemetry of heart rate as a possible method of estimating energy expenditure in the redshank *Tringa totanus* (L.). *In:* CJ Amlaner, Jr. and DW Macdonald, *A handbook on biotelemetry and radio tracking.* Oxford, Pergamon Press, pp. 595-601.

Gales, R, Williams, C, and Ritz, D. 1990. Foraging behaviour of the little penguin, *Eudyptula minor*: initial results and assessment of instrument effect. *Journal of Zoology (London), Vol. 220*: 61-85.

Gallagher, MD, Scott, DA, Ormond, RFG, Connor, RJ, and Jennings, MC. 1984. The distribution and conservation of seabirds breeding on the coasts and islands of Iran and Arabia. In: JP Croxall, PGH Evans, and RW Schreiber (eds.), *Status and conservation of the world's seabirds.* Cambridge, International Council for the Preservation of Birds (ICBP) Technical Publication No. 2, pp. 421-456.

Greenpeace International. 1990. Report on a visit to Dumont d'Urville, Antarctica. *Polar Record, Vol. 26(156)*: 54.

Greenwood, RJ, and Sargeant, AB. 1973. Influence of radio packs on captive mallards and blue-winged teal. *Journal of Wildlife Management, Vol. 37(1)*: 3-9.

Groscolas, R. 1990. Metabolic adaptations to fasting in emperor and king penguins. *In:* LS Lloyd and JT Darby (eds.), *Penguin biology*. San Diego, Academic Press, pp. 269-296.

Groscolas, R, and Leloup, J. 1989. The effect of severe starvation and captivity stress on plasma thyroxine and triiodothyronine concentrations in an Antarctic bird (emperor penguin). *General and Comparative Endocrinology, Vol. 73*: 108-117.

Halle, LJ. 1973. Life on the brink. *Audubon, Vol. 75(2):* 50-71

Hampson, J. 1992. The secret world of animal experiments. *New Scientist, Vol. 134(1816):* 24-27.

Harris, CM. 1991. Environmental effects of human activities on King George Island, South Shetland Islands, Antarctica. *Polar Record, Vol. 27(162):* 193-204.

Hart, P. 1988. The growth of Antarctic tourism. *Oceanus, Vol. 31(2): 93-100.*

Headland, RK. 1989. *Chronological list of Antarctic expeditions and related historical events.* Cambridge, Cambridge University Press.

Heap, J, (ed.). 1990. *Handbook of the Antarctic Treaty System, Part 2: The Antarctic Environment*, 7th ed. Cambridge, Polar Publications.

Heise, M. 1989. Human-induced tachycardia in wild and tame mallard (*Anas platyrhynchos*). *Comparative Biochemistry and Physiology, Vol. 92A: 125-128.*

Hemmings, AD. 1990. Human impacts and ecological constraints on skuas. *In:* KR Kerry and G Hempel (eds.), *Antarctic ecosystems: ecological change and conservation.* Heidelberg, Springer-Verlag, pp. 224-230.

Henry, JP. 1976. Mechanisms of psychosomatic disease in animals. *Advances in veterinary science and comparative medicine, Vol. 20*: 115-145.

Hill, LA, and Talent, LG. 1990. Effects of capture, handling, banding, and radio-marking on breeding least terns and snowy plovers. *Journal of Field Ornithology, Vol. 61(3)*: 310-319.

Hinde, RA. 1966. *Animal behaviour: a synthesis of ethology and comparative psychology.* New York, McGraw-Hill.

Hughes, BO, and Black, AJ. 1976. The influence of handling on egg production, egg shell quality and avoidance behaviour of hens. *British Poultry Science, Vol. 17:* 135-144.

International Union for the Conservation of Nature and Natural Resources (IUCN). 1991. *A strategy for Antarctic conservation.* Gland, International Union for the Conservation of Nature and Natural Resources.

Jones, RB, and Faure, JM. 1981. The effects of regular handling on fear responses in the domestic chick. *Behavioural Processes, Vol. 6*: 135-144.

Jones, RB, Duncan, IJH, and Hughes, BO. 1981. The assessment of fear in domestic hens exposed to a looming human stimulus. *Behavioural Processes, Vol. 6:* 121-134.

Jouventin, P. 1982. Visual and vocal signals in penguins, their evolution and adaptive characters. *Advances in Ethology (supplements to Journal of Comparative Ethology), Vol. 24.* Berlin, Parey.

Jouventin, P, Stahl, JC, Weimerskirch, H, and Mougin, JL. 1984. Seabirds of the French subantarctic islands and Adelie Land, their status and conservation. *In:* JP Croxall, PGH Evans, and RW Schreiber (eds.), *Status and conservation of the world's seabirds.* Cambridge, International Council for the Preservation of Birds (ICBP) Technical Publication No. 2, pp. 609-625.

Jouventin, P. and Bretagnolle, V. 1990. French biologists reply to Greenpeace report. *Polar Record, Vol. 26(156)*: 54.

Jouventin, P, and Weimerskirsch, H. 1990. Long-term changes in seabird and seal populations in the Southern Ocean. *In:* KR Kerry and G Hempel (eds.), *Antarctic ecosystems: ecological change and conservation.* Heidelberg, Springer-Verlag, pp. 208-213.

Kimmich, HP. 1979. Artifact free measurement of biological parameters: biotelemetry, a historical review and layout of modern developments. *In:* CJ Amlaner, Jr. and DW Macdonald, *A handbook on biotelemetry and radio tracking.* Oxford, Pergamon Press, pp. 3-20.

Kooyman, GL, and Mullins, JL. 1990. Ross Sea emperor penguin breeding populations estimated by aerial photography. *In:* KR Kerry and G Hempel (eds.), *Antarctic ecosystems: ecological change and conservation.* Heidelberg, Springer-Verlag, pp. 169-176.

Laws, R. 1991. Unacceptable threats to Antarctic science. *New Scientist,* Vol. 129(1969): 4.

Lipps, JH. 1978. Man's impact along the Antarctic Peninsula. *In:* BC Parker and MC Holliman (eds.), *Environmental Impact in Antarctica.* Virginia, Virginia Polytechnic Institute, pp. 333-371.

Lishman, GS. 1985. The comparative breeding biology of Adelie *Pygoscelis adelaie* and chinstrap *Pygoscelis antarctica* penguins at Signy Island, South Orkney Islands. *Ibis, Vol. 127*: 84-99.

McFarland, D. 1985. *Animal behaviour.* Essex, Longman Scientific & Technical.

Maier, SF, and Seligman, MEP. 1976. Learned helplessness: theory and evidence. *Journal of Experimental Psychology General, Vol. 105*: 3-46.

Manheim, BS, Jr. 1988. *On thin ice: the failure of the National Science Foundation to protect Antarctica. Washington DC, Environmental Defense Fund.*

Manheim, BS, Jr. 1990. *Paradise Lost? The need for environmental regulation of tourism in Antarctica*. Washington DC, Environmental Defense Fund.

Manser, C. 1992. Telltale signs of a stressful life. *New Scientist, Vol. 134(1818)*: 34-36.

Marchant, S and Higgins, PJ. 1990. *Handbook of Australian, New Zealand and Antarctic birds. Volume 1: Ratites to ducks*. Melbourne, Oxford University Press.

May, J. 1988. *The Greenpeace book of Antarctica*. London, Dorling Kindersley.

Moberg, GP. 1985a. Biological response to stress: key to assessment of animal well-being? *In:* GP Moberg (ed.), *Animal stress*. Maryland, American Physiological Society.

Moberg, GP (ed.). 1985b. *Animal stress*. Maryland, American Physiological Society.

Montague, TL and Cullen, JM. 1985. Comparison of techniques to recover stomach contents from penguins. *Australian Wildlife Research, Vol. 12*: 327-330.

Monteath, C. 1989. Tourism in our "frozen outback". *Australian Geographic*, Vol. 16: 17-18.

Muller-Schwarze, D, and Belanger, P. 1978. Man's impact on Antarctic birds. *In:* BC Parker and MC Holliman (eds.), *Environmental impact in Antarctica*. Blacksburg, Virginia, Virginia Polytechnic Institute, pp. 373-383.

Muller-Schwarze, D. 1984. *The behaviour of penguins*. Albany, State University of New York Press.

Murphy, RC. 1959. History of the penguins. *Natural history, Vol. 68*: 153-160.

National Parks and Wildlife Service. 1987. *Macquarie Island Nature Reserve: visitor's handbook*. Sandy Bay (Tasmania), National Parks and Wildlife Service.

Naveen, R, De Roy, T, Jones, M, and Monteath, C. 1989. Antarctic Traveler's Code announcement. *Antarctic Century, Vol. 4*: 5-6.

Nelson, B. 1980. *Seabirds: their biology and ecology*. London, Hamlyn.

Nimon, AJ. 1990. Making the zoo a positive educational experience. *Bulletin of Zoo Management, Vol. 28*: 17-20.

Nimon, AJ, and Dalziel, FR. 1992. Cross-species interaction and communication: a study method applied to captive siamang (*Hylobates syndactylus*) and long-billed corella (*Cacatua tenuirostris*) contacts with humans. *Applied Animal Behaviour Science, Vol. 33(2,3)*: 261-272.

Oelke, H. 1975. Breeding behaviour and success in a colony of Adelie penguins at Cape Crozier, Antarctica. *In*: B Stonehouse (ed.), *The biology of penguins*. London, Macmillan, pp. 363-396.

Ollason, JC, and Dunnet, GM. 1980. Nest failures in the fulmar: the effect of observers. *Journal of Field Ornithology, Vol. 51*: 39-54.

Owen, RB, Jr. 1969. Heart rate, a measure of metabolism in blue-winged teal. *Comparative Biochemistry and Physiology, Vol. 31*: 431-436.

Patterson, IJ. 1978. Tags and other distant-recognition markers for birds. *In:* B Stonehouse (ed.), *Animal marking: recognition marking of animals in research*. London, Macmillan, pp. 54-62.

Perry, G. 1973. Can the physiologist measure stress? *New Scientist, Vol. 60*: 175-177.

Peterson, RT. 1973a. Penguins of the world. *Audubon, Vol. 75(2)*: 61-68.

Peterson, RT. 1973b. Render the penguins, butcher the seals: The Antarctic's bloody past may foretell its future. *Audubon, Vol. 75(2)*: 90-109.

Piatt, JF, Roberts, BD, Lidster, W, Wells, JL, and Hatch, SA. 1990. Effects of human disturbance on breeding least and creasted auklets at St. Lawrence Island, Alaska. *The Auk, Vol. 107*: 342-350.

Poole, A. and Shoukimas, J. 1982. A scale for weighing birds at habitual perches. *Journal of Field Ornithology, Vol. 53(4)*: 409-414.

Porter, E. 1988. *Antarctica*. New York, Arch Cape Press.

Prince, PA, and Walton, DWH. 1984. Automated measurement of meal sizes and feeding frequency in albatrosses. *Journal of Applied Ecology, Vol. 21*: 789-794.

Quilty, P. 1986. Formulating the future. *Australian Natural History, Vol. 22(3):* 116-118.

Randall, RM, and Davidson, IS. 1981. Device for obtaining food samples from the stomachs of jackass penguins. *South African Journal of Wildlife Research, Vol. 11*: 121-125.

Reid, BE. 1968. An interpretation of the age structure and breeding status of an Adelie penguin population. *Notornis 15:* 193-197.

Rice, DW. 1964. The Hawaiian monk seal. *Natural History, Vol. 73*: 48-55.

Richdale, LE. 1957. *A population study of penguins*. Oxford, Clarendon Press.

Robertson, G. 1990. Huddles. *Australian Geographic, Vol. 20*: 74-97.

Roszak, T. 1988. Leave the wilderness alone! *New Scientist, Vol. 118(1615):* 63-64.

Rounsevell, D, and Binns, D. 1991. Mass deaths of king penguins (*Aptenodytes patagonica*) at Lusitania Bay, Macquarie Island. *Aurora, Vol. 10(4)*: 8-10.

Royal Australasian Ornithologist's Union (RAOU). 1990. Trouble with penguins. *RAOU Newsletter, Vol. 85*: 8-9.

Sadleir, RMF, and Lay, KM. 1990. Foraging movements of Adelie penguins (*Pygoscelis adeliae*) in McMurdo Sound. *In:* LS Davis and JT Darby (eds.), *Penguin biology*. San Diego, Academic Press, pp. 157-179.

Scientific Committee on Antarctic Research (SCAR, Conservation Subcommittee of the Working Group on Biology). 1984. *A visitor's introduction to the Antarctic and its environment*. Cambridge, British Antarctic Survey.

Scott, D. 1978. Identification of individual Bewick's swans by bill patterns. *In:* B Stonehouse (ed.), *Animal marking: recognition marking of animals in research*. London, Macmillan, pp. 160-168.

Scott, RF. 1968. *Scott's last expedition: the personal journals of Captain Robert Falcon Scott, C.V.O., R.N., on his journey to the South Pole*. London, John Murray (12th printing).

Sibly, RM, and McCleery, RH. 1980. A balance for weighing ground nesting birds. *Journal of Applied Ecology, Vol. 17*: 323-327.

Simpson, GG. 1976. *Penguins past and present, here and there*. New Haven, Yale University Press.

Sladen, WJL. 1956. Social structure among penguins: group interchange. *In*: B Schaffner (ed.), *Group processes*. New York, Josiah Macy, Jr. Foundation.

Sladen, WJL, and Penney, RL. 1960. Penguin flipper-bands used by the USARP [United States Antarctic Research Program] bird-banding program 1958-60. *Bird-Banding Vol. 31:* 79-82.

Sladen, WJL, Boyd, JC, and Pederson, JM. 1966a. Biotelemetry studies on penguin body temperatures. *Antarctic Journal of the United States, Vol. 1(4)*: 142-143.

Sladen, WJL, Wood, RC, and Emison, WB. 1966b. Antarctic avian population studies, 1965-1966. *Antarctic Journal of the United States, Vol. 1(4)*: 141-142.

Sladen, WJL, LeResche, RE, and Wood, RC. 1968a. Antarctic avian population studies, 1967-1968. *Antarctic Journal of the United States, Vol. 3*: 247-249.

Sladen, WJL, Wood, RC, and Monaghan, EP. 1968b. The USARP Bird Banding Program, 1958-1962. *Antarctic Research Series, Vol. 12*: 213-262.

Sladen, WJL, and LeResche, RE. 1970. New and developing techniques in Antarctic ornithology. *In:* MW Holdgate (ed.), *Antarctic ecology*, Volume one. London, Academic Press, pp. 585-596.

Smith, D. 1989. Macquarie airdrop. *Australian Geographic, Vol. 16*: 52-57

Spencer, R. 1978. Ringing and related durable methods of marking birds. *In:* B Stonehouse (ed.), *Animal marking: recognition marking of animals in research*. London, Macmillan, pp. 43-53.

Spurr, EB. 1975. Communication in the Adelie penguin. *In:* B Stonehouse, *The biology of penguins*. London, Macmillan Press, pp. 449-501.

Stonehouse, B. 1960. The king penguin *Aptenodytes patagonica* of South Georgia: I. Breeding behaviour and development. *Falkland Islands Dependencies Survey, Scientific Reports, No. 23.* London, F.I.D.S.

Stonehouse, B. 1965a. Animal Conservation in Antarctica. *New Zealand Science Review, Vol. 23(1)*: 3-7.

Stonehouse, B. 1965b. Counting Antarctic animals. *New Scientist, Vol. 25:* 273-276.

Stonehouse, B. 1969. Air census of two colonies of Adelie penguins (*Pygoscelis adelaie*) in the Ross Dependency, Antarctica. *The Polar Record, 14(91):* 471-475.

Stonehouse, B. 1972. *Animals of the Antarctic: the ecology of the far south.* Peter Lowe.

Stonehouse, B. 1985. Birds and mammals-Penguins. *In:* WN Bonner and DWH Walton (eds.), *Key environments, Antarctica.* Oxford, Pergamon Press, pp.266-291.

Stonehouse, B. 1990. A traveller's code for Antarctic visitors. *Polar Record, Vol. 26(156)*: 56-58.

Stonehouse, B. 1992. Monitoring shipborne visitors in Antarctica: a preliminary field study. *Polar Record, Vol. 28(166)*: 213-218.

Stout, JF, and Schwab, ER. 1979. Telemetry of heart rate as a measure of the effectiveness of dispersal inducing stimuli in seagulls. *In:* CJ Amlaner, Jr. and DW Macdonald, *A handbook on biotelemetry and radio tracking.* Oxford, Pergamon Press, pp.603-610.

Tangley, L. 1988. Who's polluting Antarctica? *Bioscience, Vol. 38(9):* 590-593.

Taylor, RH, Wilson, PR, and Thomas, BW. 1990. Status and trends of Adelie penguin populations in the Ross Sea region. *Polar Record 26(159):* 293-304.

Tickell, WLN. 1968. Color-dyeing albatrosses. *Bird-Banding, Vol. 39(1)*: 36-40.

Tinbergen, N. 1953. *Social behaviour in animals with special reference to vertebrates (2nd ed.): Science Paperback Series, 1.* London, Chapman & Hall.

Trivelpiece, WZ, Bengston, JL, Trivelpiece, SG, and Volkman, NJ. 1986. Foraging behaviour of gentoo and chinstrap penguins as determined by new radio telemetry techniques. *Auk, Vol. 103*: 777-781.

Trivelpiece, WZ, Trivelpiece, SG, and Volkman, NJ. 1987. Ecological segregation of Adelie, gentoo and chinstrap penguins at King George Island, Antarctica. *Ecology, Vol. 68(2)*: 351-361.

Trivelpiece, WZ, Trivelpiece, SG, Geupel, GR, Kjelmyr, J, and Volkman, NJ. 1990. Adelie and chinstrap penguins: their potential as monitors of the Southern Ocean marine ecosystem. *In:* KR Kerry and G Hempel (eds.), *Antarctic ecosystems: ecological change and conservation.* Heidelberg, Springer-Verlag, pp 191-202.

Van Heezik, Y, and Seddon, PJ. 1990. Effect of human disturbance on beach groups of jackass penguins. *South African Journal of Wildlife Research, Vol. 20(3)*: 89-93.

Weimerskirch, H. Stahl, JC, and Jouventin, P. 1992. The breeding biology and population dynamics of king penguins *Aptenodytes patagonica* on the Crozet Islands. *Ibis, Vol. 134*: 107-117.

Willams, AJ, Cooper, J, Newton, IP, Phillips, BP, and Watkins, BP. 1985. *Penguins of the world: a bibliography.* Cambridge, British Antarctic Survey.

Wilson, K-J, Taylor, RH, and Barton, KJ. 1990a. The impact of man on Adelie penguins at Cape Hallett, Antarctica. *In:* KR Kerry and G Hempel (eds.), *Antarctic ecosystems: ecological change and conservation.* Heidelberg, Springer-Verlag, pp. 183-190.

Wilson, RP. 1984. An improved stomach pump for penguins and other seabirds. *Journal of Field Ornithology, Vol. 55(1)*: 109-112.

Wilson, RP, and Bain, CAR. 1984a. An inexpensive depth gauge for penguins. *Journal of Wildlife Management, Vol. 48(4)*: 1077-1084.

Wilson, RP, and Bain, CAR. 1984b. An inexpensive speed meter for penguins at sea. *Journal of Wildlife Management, Vol. 48(4)*: 1360-1364.

Wilson, RP, and Wilson, M-PT. 1989. A peck activity record for birds fitted with devices. *Journal of Field Ornithology 60(1)*: 104-108.

Wilson, RP, Coria, NR, Spairani, HJ, Adelung, D, and Culik, B. 1989. Human-induced behaviour in Adelie penguins *Pygoscelis adeliae. Polar Biology, Vol. 10*: 77-80.

Wilson, RP, Spairani, HJ, Coria, NR, Culik, BM, and Adelung, D. 1990b. Packages for attachment to seabirds: what colour do Adelie penguins dislike least? *Journal of Wildlife Management, Vol. 54(3)*: 447-451.

Wilson, RP, Culik, B, Danfeld, R, and Adelung, D. 1991. People in Antarctica-how much do Adelie penguins *Pygoscelis adeliae* care? *Polar Biology, Vol. 11*: 363-371.

Woehler, EJ. 1990. Two records of seabird entanglement at Casey, Antarctica, *Marine Ornithology, Vol. 18(1,2)*: 72-73.

Wood, RC, LeResche, RE, and Sladen, WJL. 1967. Antarctic avian population studies, 1966-1967. *Antarctic Journal of the United States, Vol. 2(4)*: 101-103.

**Appendix 1:** Preamble and Articles 1-3 of the *Protocol on Environmental Protection to the Antarctic Treaty.*

## PROTOCOL ON ENVIRONMENTAL PROTECTION TO THE ANTARCTIC TREATY.

### PREAMBLE

The States Parties to this Protocol to the Antarctic Treaty, hereinafter referred to as the Parties,

Convinced of the need to enhance the protection of the Antarctic environment and dependent and associated ecosystems;

Convinced of the need to strengthen the Antarctic Treaty system so as to ensure that Antarctica shall continue forever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord;

Bearing in mind the special legal and political status of Antarctica and the special responsibility of the Antarctic Treaty Consultative Parties to ensure that all activities in Antarctica are consistent with the purposes and principles of the Antarctic Treaty;

Recalling the designation of Antarctica as a Special Conservation Area and other measures adopted under the Antarctic Treaty system to protect the Antarctic environment and dependent and associated ecosystems;

Acknowledging further the unique opportunities Antarctica offers for scientific monitoring of and research on processes of global as well as regional importance;

Reaffirming the conservation principles of the Convention on the Conservation of Antarctic Marine Living Resources;

Convinced that the development of a comprehensive regime for the protection of the Antarctic environment and dependent and associated ecosystems is in the interest of mankind as a whole;

Desiring to supplement the Antarctic Treaty to this end;

Have agreed as follows:

## ARTICLE 1

*DEFINITIONS*

For the purposes of this Protocol:

(a) "The Antarctic Treaty" means the Antarctic Treaty done at Washington on 1 December 1959;

(b) "Antarctic Treaty area" means the area to which the provisions of the Antarctic Treaty apply in accordance with Article VI of that Treaty;

(c) "Antarctic Treaty Consultative Meetings" means the meetings referred to in Article IX of the Antarctic Treaty;

(d) "Antarctic Treaty Consultative Parties" means the Contracting Parties to the Antarctic Treaty entitled to appoint representatives to participate in the meetings referred to in Article IX of that Treaty;

(e) "Antarctic Treaty system" means the Antarctic Treaty, the measures in effect under that Treaty, its associated separate international instruments in force and the measures in effect under those instruments;

(f) "Arbitral Tribunal" means the Arbitral Tribunal established in accordance with the Schedule to this Protocol, which forms an integral part thereof;

(g) "Committee" means the Committee for Environmental Protection established in accordance with Article 11

ARTICLE 2

*OBJECTIVE AND DESIGNATION*

The Parties commit themselves to the comprehensive protection of the Antarctic environment and dependent and associated ecosystems and hereby designate Antarctica as a natural reserve, devoted to peace and science.

## ARTICLE 3

### *ENVIRONMENTAL PRINCIPLES*

1. The protection of the Antarctic environment and dependent and associated ecosystems and the intrinsic value of Antarctica, including its wilderness and aesthetic values and its value as an area for the conduct of scientific research, in particular research essential to understanding the global environment, shall be fundamental considerations in the planning and conduct of all activities in the Antarctic Treaty area.

2. To this end:

(a) activities in the Antarctic Treaty area shall be planned and conducted so as to limit adverse impacts on the Antarctic environment and dependent and associated ecosystems;

(b) activities in the Antarctic Treaty area shall be planned and conducted so as to avoid:

(i) adverse effects on climate or weather patterns;

(ii) significant adverse effects on air or water quality;

(iii) significant changes in the atmospheric, terrestrial (including aquatic), glacial or marine environments;

(iv) detrimental changes in the distribution, abundance or productivity of species or populations of species of fauna and flora;

(v) further jeopardy to endangered or threatened species or populations of such species; or

(vi) degradation of, or substantial risk to, areas of biological, scientific, historic, aesthetic or wilderness significance;

(c) activities in the Antarctic Treaty area shall be planned and conducted on the basis of information sufficient to allow prior assessments of, and informed judgments about, their possible impacts on the Antarctic environment and dependent and associated ecosystems and on the value of Antarctica for the conduct of scientific research; such judgments shall take full account of:

(i)the scope of the activity, including its area, duration and intensity;

(ii)the cumulative impacts of the activity, both by itself and in combination with other activities in the Antarctic Treaty area;

(iii)whether the activity will detrimentally affect any other activity in the Antarctic Treaty area;

(iv)whether technology and procedures are available to provide for environmentally safe operations;

(v)whether there exists the capacity to monitor key environmental parameters and ecosystem components so as to identify and provide early warning of any adverse effects of the activity and to provide for such modification of operating procedures as may be necessary in the light of the results of monitoring or increased knowledge of the Antarctic environment and dependent and associated ecosystems; and

(vi)whether there exists the capacity to respond promptly and effectively to accidents, particularly those with potential environmental effects;

(d) regular and effective monitoring shall take place to allow assessment of the impacts of ongoing activities, including the verification of predicted impacts;

(e) regular and effective monitoring shall take place to facilitate early detection of the possible unforeseen effects of activities carried on both within and outside the Antarctic Treaty area on the Antarctic environment and dependent and associated ecosystems.

3. Activities shall be planned and conducted in the Antarctic Treaty area so as to accord priority to scientific research and to preserve the value of Antarctica as an area for the conduct of such research, including research essential to understanding the global environment.

4. Activities undertaken in the Antarctic Treaty area pursuant to scientific research programmes, tourism and all other governmental and non-governmental activities in the Antarctic Treaty area for which advance notice is required in accordance with Article VII (5) of the Antarctic Treaty, including associated logistic support activities, shall:

(a) take place in a manner consistent with the principles in this Article; and

(b) be modified, suspended or cancelled if they result in or threaten to result in impacts upon the Antarcti environment or dependent or associated ecosystems inconsistent with those principles.

Appendix 2: Penguins crowded out? (Culik and Wilson, 1991).

# Penguins crowded out?

SIR — In your review of scientific research in Antarctica you report Wayne Trivelpiece as saying (*Nature* **350**, 294; 1991) that he observed a 10–20 per cent decline in Adélie and chinstrap penguin populations near the Polish research base Arctowski in Admiralty Bay, King George Island, South Shetlands, over the past three years. He speculated that this was due to overfishing of krill in that area. He suggested that penguins be used as a monitor for krill, and that by counting penguins the krill population would be assessed. We would like to suggest that Antarctic penguins are also sensitive indicators of human interference, and that the decline in the penguin populations at Admiralty Bay may be attributed to this fact alone.

Although seemingly unconcerned, Adélie penguins react strongly to human interference during the breeding season. Heart rate is a good indicator of stress, and we found heart rates to increase by almost 50 per cent when breeding Adélie penguins were approached by a human and to increase by 270 per cent when the birds were caught and weighed in a bag[1,2]. Adélie penguins brooding large chicks fled only when approached closer than 6 metres, but a solitary human at a distance of 20 metres from commuting penguins on a well-used walkway caused the birds to deviate by 70 metres (ref. 2). Contrary to the view expressed in *Nature* (**350**, 291; 1991), we believe that tourism does adversely affect breeding penguins, almost irrespective of how "well-behaved" the tourists are.

Scientists studying penguins may also have a negative impact on the birds. Daily visits to a colony, including adult and egg measurement, reduce breeding success of the study birds when compared to non-visited colonies nearby[3], and flipper bands, widely used by Trivelpiece and his co-workers, are also liable to affect birds. Kinkel[4] reported that the use of wing tags in gulls reduced the number of birds returning to the colony, retarded the return of the others, weakened the pair bond and reduced reproductive performance. Penguins are nearly perfectly streamlined[5] and attachment of foreign bodies including flipper bands is certain to have a negative influence on their energetics and behaviour at sea[6,7].

In addition, we found that aircraft operating near a base caused birds to panic at distances greater than 1,000 metres and that three days of continuous helicopter operation caused 8 per cent of the nests to be abandoned[2]. Finally, surface-active agents such as oil, faeces and detergents originating from ships and bases destroy the waterproofing quality of the feathers and cause loss of buoyancy and insulation. Most oiled penguins die in the water, unnoticed by scientists ashore[8].

It is therefore not surprising that penguin populations are reported to be detrimentally affected by the presence of humans. At the joint US–NZ base at Cape Hallett, Antarctica, Adélie penguins declined from 62,900 pairs in 1959 to 37,000 pairs in 1968[9]. The station was abandoned in 1973, and by 1981 the number of breeding pairs had increased to 66,000[9]. The sharp decline in penguin numbers at Cape Royds between 1955 and 1963 has been attributed[10] to interference by visitors on foot and to helicopters flying over the colony. Since the restriction of human activity in that area, the population has recovered. Recently, Woehler *et al.*[11] found that at Shirley Island, near Australia's Casey station, the Adélie penguin population had increased by 209 per cent everywhere but in the vicinity of the base, where numbers were stagnating.

Scientists in our department have spent several field seasons in Admiralty Bay, and report that the area is increasingly affected by tourism. Tourists and personnel often approach and enter colonies within the 'sites of special scientific interest'. And the operation of scientific vessels and supply ships, often with helicopters, further increases disturbance throughout the breeding season. King George Island is the most densely populated area in Antarctica, with eight stations being operated year round and a large number of summer camps, with all the associated problems of disturbance, sewag and pollution.

If penguin numbers are to be used t monitor the krill population, the study site a well as the methods employed by the scien tists in the field need to be very carefull selected. Neither is the case in the studie conducted on King George Island.

BORIS CULIK
RORY WILSO

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1. Culik, B., Adelung, D. & Woakes, A. J. in *Antarctic Ecosys tems. Ecological Change and Conservation.* (eds Kerry, K R. & Hempel, G.) 177–182, (Springer, Berlin, 1990).
2. Wilson, R. P. *et al. Polar Biol.* (in the press).
3. Lishman, G. S. *Ibis* **127**, 84–99 (1985).
4. Kinkel, L. K. *Auk* **106**, 619–624 (1989).
5. Nachtigall, W. & Bilo, D. J. *comp. Physiol. A* **137**, 17–2 (1980).
6. Wilson, R. P. *et al. Polar Biol.* **10**, 77–80 (1989).
7. Culik, B. & Wilson R. P. *J. exp. Biol.* (in the press).
8. Culik, B. *et al. Mar. Pollut. Bull.* (in the press).
9. Wilson, K.-J., Taylor, R. H. & Barton, K. J. in *Antarctic Ecc systems. Ecological Change and Conservation.* (ed Kerry, K. R. & Hempel G.) 183–190 (Springer, Berlir 1990).
10. Thompson, R. B. in *Adaptations within Antarctic Ecosys tems.* (ed. Llano, G. A.) 1177–1180 (Smithsonian Institu tion, Washington, DC, 1977).
11. Woehler, E. J. *et al. Mar. Ornithology* (in the press).

## Appendix 3. New terminology (in order of appearance in text).

**Human-animal interaction** (p. 4): According to the definition by Nimon and Dalziel (1992), human-animal interaction can be described as a situation in which the behaviour of a human or humans affects the behaviour of a member or members of another species. The effect of one interactant's behaviour on the other's can be identified only through a change in the latter's behaviour. Thus, human disturbance of Antarctic animals can be understood in terms of interaction, a perspective which encourages identification of all human-induced behavioural change, rather than just that which appears obviously harmful.

**Penguin mob behaviour theory** (p. 27): Given the social nature of Antarctic penguin life, it is suggested that the behaviour of congeners provides potent stimuli which evoke, modify and reinforce much of the behaviour of the individual. These stimuli are, therefore, also likely to determine response to new or unusual stimuli induced by humans.

**Basic penguin reaction to aircraft** (p. 29): The graded sequence of response - stop moving, walk, run, toboggan away from source of disturbance - may represent the basic penguin reaction to all large, highly-salient, fear-evoking stimuli. Response thresholds probably vary with species, and influences of different breeding stages, such as the presence of eggs or small chicks, might affect or inhibit the reaction. There is evidence to suggest that there is a great qualitative distinction between the first response and the following three (p. 34).

**Synergistic congener effect** (p. 34): When a large proportion of surrounding penguins are disturbed to a high degree, then the response of one is determined by both the disturbing stimulus and the reaction of congeners, in a synergistic way. There is evidence to suggest that this effect will not only evade habituation, but will augment with subsequent exposure (p. 35).

**Human approach model** (p. 58): A derived model which attempts to identify what stimuli may be emitted by a single human as he or she gradually approaches a single penguin, and the reactions of the bird to those stimuli.

**Danger threshold distance (DTD)** (59): Part of the human approach model. The distance at which a gradually approaching human ceases to be merely an unusual feature of the environment, and becomes threatening, assuming that prior predator learning has not occurred. It is identified by an increment or change in response. Habituation to a person may be more easily achieved if the person remains beyond the DTD, and the DTD should gradually decrease with such learning.

**Predator learning theory** (p. 61): A certain category of human behaviour will represent predator behaviour to a penguin. Removal or manipulation of offspring, and highly threatening actions such as handling adults, are included. Manipulation of nesting birds (without removal) and very close approach may also belong to this category. The learnt association between people and this predator behaviour will be particularly strong and will influence subsequent reaction to humans.

**Predator response** (p.64): Response of penguin to a human acting as a predator, or to any human once the penguin has learnt that people are predators. One example is the increase in internal temperature exhibited by Boyd and Sladen's (1971) birds during handling (p.62); another is the enormous HR increase measured by Culik et.al (1990) and Wilson et.al (1991) in response to approach by a person (p.64).

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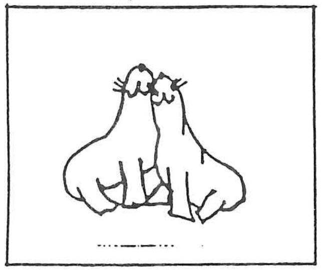
**Appendix 4:** Visitor's Guide to the Antarctic: a document published by the National Science Foundation which is distributed on some Antarctic-bound ships as a guide to reducing impact on the environment.

# VISITORS' GUIDE TO THE ANTARCTIC

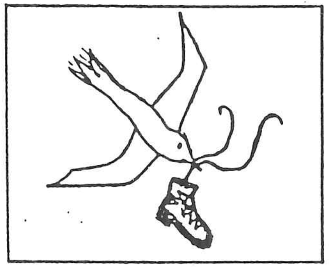
## CARE FOR THE ENVIRONMENT



**The Antarctic environment can easily be damaged. Please respect it.**

- Plants are rare, fragile and slow growing. Avoid walking on moss and lichens. It takes years for these to recover.
- Do not collect organic matter such as lichens and mosses.
- If birds or seals react to your presence, you are too close. Keep your distance!
- Allow fossils and rocks to remain undisturbed.
- Keep to established tracks or trails. Avoid walking on undisturbed ground.
- Be sensitive in the way you take photographs. Do not disturb plants or animals to enhance your pictures.

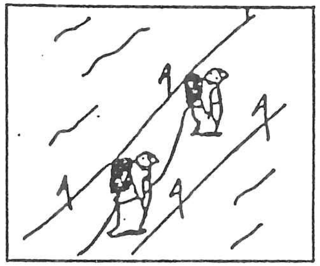
## LITTER AND HUMAN IMPACT



**In Antarctica it can take decades for human trash or artifacts to break down.**

- Take all your litter with you.
- Do not throw litter overboard from ships.
- The Antarctic Treaty's Code of Conduct on Waste Management provides solid guidance on minimizing adverse effects of human presence.
- Avoid trampling of sites.
- Please respect historic sites. They are protected by the Antarctic Treaty.
- Emergency depots and refuges must not be disturbed.

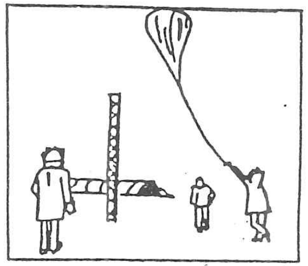
## SAFETY



**Antarctica is a very hazardous place.**

- Be alert!
- Plan your activities with safety in mind at <u>all</u> times.
- Be prepared to survive in the cold.
- Be self-sufficient in your plans and the equipment you carry.
- Do not expect a rescue service.
- Learn about Antarctic hazards
- Always stay with your group.

## SCIENCE STATIONS AND PROGRAMS



**Research in Antarctica is making a special contribution to international understanding of the globe.**

- Check with the station managers in the area you are visiting <u>before</u> you visit Antarctica. They can inform you of their activities.
- Stations are home for antarctic personnel. Please respect their property and privacy.
- Do not disturb sites where scientific research is going on.
- Check on the research activities that are underway in the area you are visiting.
- Do not automatically expect support from research stations. They are not set up as visitor hostels.

NSF 90-147

**Appendix 5:** The Antarctic Traveler's Code (ATCO).

# Antarctic Traveler's CODE

## Antarctic Visitors

- **MUST** ***NOT*** leave footprints in fragile mosses, lichens, or grasses.
- **MUST** ***NOT*** dump plastic or other, non-biodegradable garbage overboard or onto the Continent.
- **MUST** ***NOT*** violate the seals', penguins', or seabirds' Personal Space

  — start with a "baseline" distance of: 15 feet (5 meters) from penguins, seabirds, and true seals and 60 feet (18 meters) from fur seals
  — give animals the right-of-way
  — stay on the edge of, and don't walk through, animal groups
  — back-off if necessary
  — never touch the animals.

- **MUST** ***NOT*** interfere with protected areas or scientific research.
- **MUST** ***NOT*** take souvenirs.

## Antarctic Tour Companies

- **SHOULD** apply the Antarctic Traveler's Code to all officers, crew, staff and passengers.
- **SHOULD** utilize one (1) guide or leader for every twenty (20) passengers.
- **SHOULD** employ experienced and sensitive on-board leadership.
- **SHOULD** use vessels that are safe for Antarctic ice conditions.
- **SHOULD** adopt a shipwide anti-dumping pledge.

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**Appendix 6:** Antarctica Visitor Guidelines (ATCP, 1991b)

## Antarctica Visitor Guidelines

Antarctica, the world's last pristine wilderness, is particularly vulnerable to human presence. Not only must life in the Antarctic contend with one of the harshest environments on earth, but an ever-increasing human presence is adding a greater amount of stress to the fragile and unique ecosystem.

Recognizing this, the following Visitor Guidelines have been adopted by all of the U.S. ship tour operators and will be made available to all visitors traveling with them to Antarctica. With your cooperation we will be able to operate environmentally-conscious expeditions which will protect and preserve Antarctica, leaving the continent unimpaired for future generations. We ask you to thoroughly study and follow these guidelines. By doing so, you will make an important contribution towards the conservation of the Antarctic ecosystem, and avoid potentially harmful and long-lasting damage.

1. **Maintain a distance of at least 15-20 feet from penguins, nesting birds and crawling seals, and 50 feet from fur seals.** Most of the Antarctic species exhibit a lack of fear which allows you to approach closely; however, please remember that the austral summer is a time for courting, mating, nesting and rearing young. If you approach the animals or birds too closely you may startle and disturb them sufficiently that they will abandon the nesting site, leaving eggs or chicks vulnerable to predators. And even from the recommended distance you will be able to obtain fantastic photographs.

You should also remember that wild animals, especially seals, are extremely sensitive to movement and a person's height above the ground in relation to their size. Approach wildlife slowly when preparing to take photographs. And it is important to remember that your photography is not over when the shutter clicks — make your retreat from the subject in the same way you approach. The key point to remember is not to cause the animals any distress. You should be careful to avoid altering their natural behavior.

2. **Be alert while you are ashore!** Watch your step in order not to stumble upon an aggressive fur seal or a nesting bird that is unaware of your presence. And pay attention to the behavior of flying birds, as well as those on the ground. For example, when a tern or skua becomes excited or agitated and starts "dive-bombing" you, it is a good indication that you are walking too close to its nest, though you may have not have spotted it.

3. **Do not get between a marine animal and its path to the water, nor between a parent and its young.** Never surround a single animal, nor a group of animals, and always leave them room to retreat. Animals always have the right-of-way!

4. **Be aware of the periphery of a rookery or seal colony, and remain outside it.** Follow the instructions given by your leaders.

5. **Do not touch the wildlife.** The bond between parent and young can be disrupted, and the survival of the young jeopardized.

6. **Never harass wildlife for the sake of photography.** Our intention is to observe wildlife in its natural state.

7. **Keep all noise to a minimum in order not to stress the animals.**

8. **Avoid walking on, stepping on, or damaging the fragile mosses and lichens.** Regeneration is extremely slow and the scars from human damage last for decades.

9. **Take away only memories and photographs.** Do not remove anything, not even rocks or limpet shells. This includes historical evidence of man's presence in Antarctica, such as whalebones seen at some sites, which resulted from the whaling industry's activities.

10. **Return all litter to the ship for proper disposal.** This includes litter of all types, such as film containers, wrappers, and tissues. Garbage takes decades to break down in this harsh environment.

11. **Do not bring food of any kind ashore.**

12. **Do not enter buildings at the research stations unless invited to do so.** Remember that scientific research is going on, and any intrusion could affect the scientists' data. Be respectful of their work.

13. **Historic huts can only be entered when accompanied by a specially-designated governmental representative or properly authorized ship's leader.**

14. **Smoking is prohibited when ashore!**

15. **When ashore stay with the group and/or one of the ship's leaders.** For your own safety, do not wander off on your own.

16. **Listen to the Expedition Leader, Lecturers and Naturalists.** They are experienced and knowledgeable about Antarctica. If you are not sure about something, please don't hesitate to ask your leaders and guides.

**Appendix 7:** Wilson et.al's (1991, p.369) recommendations.

1) Any work conducted during the austral summer that is likely to disturb penguins should be carried out after chicks have fledged, otherwise when birds are incubating and have been incubating for at least 10 days. The latter period generally occurs at the end of November; chicks fledge in February (Ainley et.al 1983).

2) Potentially disturbing work should be carried out around midday.

3) Nesting birds should not be approached by humans on foot closer than 100m unless absolutely necessary.

4) Penguins moving on routes between the colony and the sea should not be approached by humans on foot closer than 100m unless absolutely necessary.

5) Aircraft should use the same flight path for serial drops and Super Puma helicopters should not approach a colony closer than 1,000m horizontally and 200m vertically.

6) Many more Specially Protected Areas should be established in the Antarctic under provision of the Antarctic Treaty.

7) Provisions in the Antarctic Treaty should be made to prohibit establishment of bases within 1 km of penguin colonies.